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Astronomy

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July 2002

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LX200GPS
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Right-to-left: *Meade 8", 10", and 12" LX200GPS Schmidt-Cassegrain telescopes. Manufactured under U.S. Patent No. 6,304,376; other patents pending in the U.S.A. and worldwide.*

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Meade® LX200GPS: the most important advance in Schmidt-Cassegrain technology in ten years is here.

For the visual observer, the astrophotographer, the CCD imager: all the telescope you could possibly have imagined.

For the advanced amateur, new Meade LX200GPS telescopes offer absolutely state-of-the-art optical, mechanical, and electronic performance unmatched by any competing models. Standard-equipment features include:

Precision GPS Alignment: Telescope alignment is accomplished automatically using integrated true-level and North electronic sensors in combination with a 16-channel GPS receiver located in the left-hand fork arm. Magnetic declination compensation is designed into the software and automatically engaged. Just press the *ENTER* button on the Autostar II hand controller and watch as the telescope slews at 8°/second to its first alignment star. *Competing GPS telescopes use a 12-channel receiver (resulting in slower and less reliable position acquisition), do not include any magnetic declination compensation, and can easily result in first-alignment-star errors of up to 20° or more.*

All LX200GPS models include the Zero Image-Shift Microfocuser as standard equipment. The primary mirror lock-knob is located directly above the manual focus knob.

Revolutionary new rear-cell systems designed for the advanced visual observer, astrophotographer and CCD imager — systems that enable new levels of precision in focusing in all applications and in image centering on CCD chips:

Primary Mirror Lock: Flip a knob located just above the manual coarse-focus knob and lock the telescope's primary mirror rigidly in place. Used in conjunction with the Zero Image-Shift Microfocuser *(below)* the primary mirror lock cancels any residual image shift while focusing during visual, photographic, or CCD imaging applications.

Zero Image-Shift Microfocuser: Now you can obtain the most precise image focus possible — truly to a microscopic level — during visual and astrophotographic applications, and, during CCD applications, simultaneously maintain precise image centration on even the smallest CCD chips. Included as standard equipment with all LX200GPS Schmidt-Cassegrain models, the Meade Zero Image-Shift Microfocuser operates at 4 different speeds from extremely slow to fast and is actuated through the Autostar II handbox. Coarse manual focusing is effected through the telescope's manual focus knob.

Autostar II: The new Autostar II control system provided with LX200GPS models includes all of the features that made previous LX200 models the largest-selling serious telescopes in the world. In addition, Autostar II includes an expanded 3.5 Megabyte memory, with a greatly enlarged database of more than 145,000 celestial objects, a database that is immediately accessible on the Autostar II display. A partial listing of the Autostar II database:

Library	No. of Objects
New General Catalog (NGC)	7840
Index Catalog (IC)	5386
Uppsala Galaxy Catalog	12,940
Morphological Catalog of Galaxies	12,939
General Catalog of Variable Stars	28,484
SAO and Hipparcos Star Catalogs	42,277
Draper Star Catalog (HD)	21,127
Yale Bright Star Catalog (BSC5)	6150
Large Bright Quasars Survey (LBQS)	1055
Messier Catalog (M)	110
Caldwell Catalog	109
Named Objects	227
Herschel Catalog	400
Abell Catalog of Galaxy Clusters	2712
Arp Catalog of Irregular Galaxies	645
Major planets from Mercury to Pluto	8

SPECIFICATIONS: 7", 8", 10", and 12" LX200GPS — Each complete telescope includes 8", 10", or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); primary mirror lock; 4-speed zero image-shift microfocuser; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and 7-port multi-function control panel, including two RS-232 serial interface ports; manual and electric slow-motion controls on both axes; Autostar II control system with 3.5-Megabyte flash memory, digital readout display, permanently programmable Smart Drive and 185-speed drive controls on both axes, High-Precision Pointing, and GO TO controller; 145,000-object onboard celestial software library; GPS alignment system with 16-channel GPS receiver, magnetic declination compensation, and true-level and North electronic sensors; 12vDC telescope power supplied from internal battery compartments accepting 8 (user-supplied) C-cells (optional 25 ft. cords available for powering from auto cigarette lighter plug or from 115vAC); 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

MEADE LX200GPS SCHMIDT-CASSEGRAIN TELESCOPES

8" LX200GPS	**$2495**
10" LX200GPS	**2995**
12" LX200GPS	**3995**
7" LX200GPS Maksutov-Cassegrain	**2995**

Ultra-High Transmission Coatings (UHTC) group increases image brightness by 20% *(see ad in June 2002 issue)*: 8" LX200GPS – $175; 10" LX200GPS – $235; 12" LX200GPS – $295; 7" LX200GPS – $150.

Packing & shipping charges in the 48 states: 8" – $105; 10" – $145; 12" – $215; 7" – $125. Prices shown are suggested U.S. national mail-order retail prices.

A COMPARISON OF GPS SCHMIDT-CASSEGRAIN TELESCOPES

	Meade LX200GPS	Competing 11" GPS*
GPS Receiver	16-channel	12-channel
Magnetic declination compensation	yes	no
True-level electronic sensor	yes	no
Primary mirror lock	yes	no
Zero image-shift microfocuser	yes	no
Maximum slew speed	8°/second	3°/second
Drive speeds, each axis	185 speeds, from .01x sidereal to 8°/sec.	9 speeds, from 0.5x sidereal to 3°/sec.
Tracking rates	sidereal, lunar, or custom-selected from 2000 rates	sidereal, lunar, or solar
Memory	3.5-Meg flash	1.0-Meg flash
GO TO pointing precision	2-arcmins	unstated
High-precision pointing mode	yes; permits GO TO pointing precision within 1-arcmin	no
Permanent Periodic Error Correction	yes, both axes	one axis only; second axis unprogrammable
Object database	147,541 objects	"40,000+"
Encoder resolution	0.14 arcsecs	0.26 arcsecs
Internal battery compartments for battery powering	yes; batteries located internal to fork arms	no
RS-232 software download	yes; object libraries and software downloads available	not currently available on factory website**
Tracking calibration	not required	recommended after changes in telescope position or load

*Based on sample and instruction manual received in 7/01. ** As of 2/5/02.

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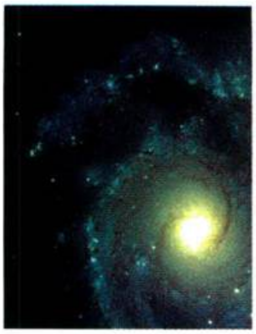

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COVER PHOTO: Galaxy NGC 2997, courtesy ESO

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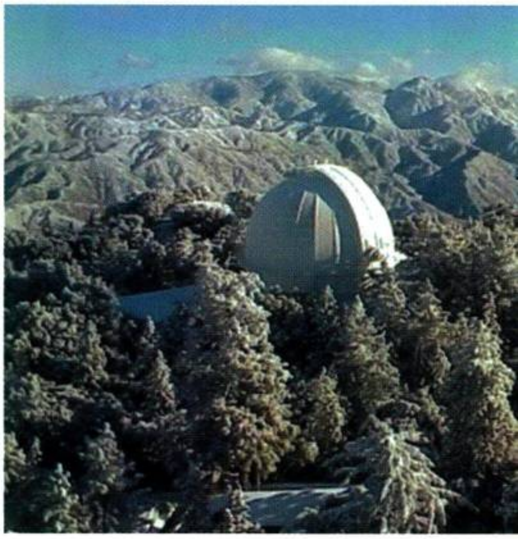

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BEHIND THE SCENES

BY BONNIE BILYEU GORDON

The Law of Everything

Each time we feature a story on cosmology or theoretical astrophysics, we receive a lot of mail. Some of the letters present competing theories offered up by individual readers. Others question the evidence for such things as string theory, membrane theory, supersymmetry, inflation, even the Big Bang. We don't blame you for being confused or challenged by such ideas; the evidence for many of these subjects is not always easy to understand. And all of the theories change as they develop.

I had the chance this spring (March 15 through 18) to sit in on conversations among about 300 theoretical astrophysicists meeting at Princeton University to discuss the latest ideas in cosmology. Many of them are well-known to you if you regularly read *Astronomy*. Quantum gravity theorist Bryce DeWitt, membrane theorist Lisa Randall, and inflation theorist Andrei Linde, also an advocate of multiple universes, were among the speakers. Alan Guth, another inflation theorist, was in the audience tartly questioning some of the speakers. Brian Greene, string theorist, was also there, listening carefully. A dozen or so journalists sat in, and at least one dramatist came looking for the next big theatrical plot from physics. Perhaps he would find another *Proof* or *Copenhagen* or even *Brilliant Mind* in these talks. The host university, after all, is home to John Nash.

Andrew C. Stewart

Black holes seem reasonable and easy to grasp compared with membrane theory.

The conference, called "Science and the Ultimate Reality," was pulled together to honor John Wheeler, whose rather famous tenure at Los Alamos was followed by discoveries useful to astronomers, many of whom he trained. Every speaker wanted to get at the Theory of Everything, a set of consistent rules that explain what happens on Earth and in the rest of the universe. Every accepted point of view was represented, and many of the speakers contradicted one another. At times these astrophysicists got cranky with one another.

The point of this story is not only to tell you that scientists disagree with one another, though quite often they do. The 300 theoretical astrophysicists who attended this meeting could agree that Quantum Theory was desirable but couldn't agree on how to find it.

It's probably no surprise to you that *Astronomy* editors sometimes squabble over the validity of a cosmology story (and other things), and less wonder that magazine readers have lots of questions. Bring them on and we'll answer those we can.

Incidentally, my conference badge at this meeting claimed I was part of *Astronomy* magazine's theoretical physics group. Quite an awesome promotion.

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70 • 90 • 105 • 125 **ETX** MEADE AUTOSTAR

"…A prediction: The ETX/Autostar concept will go down as the greatest happening in amateur astronomy yet."
— *Sky & Telescope*, May, 1999

MEADE
COMPUTER CONTROL
AUX
HBX
ON
OFF
AUX
12v
AUTOSTAR
Lagoon Nebula
Messier 8
MEADE
ENTER
MODE
GO TO
1 2 3
4 5 6
7 8 9
0
?

ETX-105EC, shown with optional #497 Autostar controller and T-Adapter.

Since their inception in 1999, Meade ETX telescopes have gone on to become the largest-selling modern telescopes in the world, with hundreds of thousands of ETX's now in the field. And every one with the unique ETX trademarks: matchless optical performance; compact, contemporary design; and revolutionary Autostar GO TO capability. *See the Meade General Catalog for full details.*

MEADE ETX ASTRO TELESCOPES

Complete per catalog specifications:

ETX-70AT with #494 Autostar	**$349**
ETX-90EC with Electronic Controller	**495**
ETX-105EC with Electronic Controller	**695**
ETX-125EC with Electronic Controller	**895**
#497 Autostar controller for ETX-90EC, ETX-105EC, or ETX-125EC	**149**

Ultra-High Transmission Coatings (UHTC) group increases image brightness by 20% *(see ad in June 2002 issue)*:
ETX-90EC– $50; ETX-105EC– $75; ETX-125EC– $95

Prices shown are suggested U.S. mail-order retail prices.

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MEADE LXD55 6" 8" 10"

SCHMIDT-NEWTONIANS WITH AUTOSTAR®

Now you can buy a Meade Schmidt-Newtonian telescope with Autostar dual-axis GO TO drive system for as little as $599, *complete!*

MEADE
LXD55
AUTOSTAR
MEADE

Shown: Meade Model SN-8 8" f/4 Schmidt-Newtonian Telescope with standard-equipment Autostar Control System

MEADE LXD55-SERIES SCHMIDT-NEWTONIAN TELESCOPES

Shipped complete per specifications below:

6" Model SN-6 Schmidt-Newtonian. .	**$599**
8" Model SN-8 Schmidt-Newtonian . . .	**729**
10" Model SN-10 Schmidt-Newtonian . .	**879**

Ultra-High Transmission Coatings (UHTC) group increases image brightness by 20% *(see ad in June 2002 issue)*: 6" Model SN-6 – $85; 8" Model SN-8 – $125; 10" Model SN-10 – $150.

Packing & shipping charges in the 48 states: 6" – $75; 8" – $85; 10" – $95. Prices shown are suggested U.S. national mail-order retail prices.

SPECIFICATIONS: Models SN-6, SN-8, and SN-10 Schmidt-Newtonian Telescopes — Each complete telescope includes 6" f/5, 8" f/4, or 10" f/4 Schmidt-Newtonian optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally); quick-release cradle ring assembly with locks; 6 x 30mm achromatic viewfinder; metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); operating instructions.

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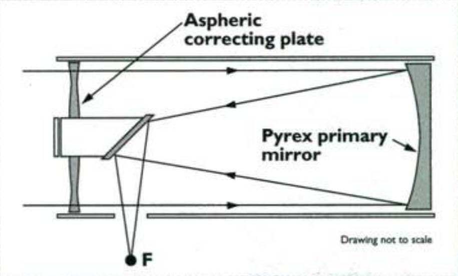
Every Meade LXD55-Series Schmidt-Newtonian telescope includes this listing of standard equipment:

Schmidt-Newtonian optical systems: Manufactured entirely at the Meade Irvine facility, LXD55 diffraction-limited Schmidt-Newtonian optics yield pinpoint stellar images over extremely wide fields, with *one-half* the coma of paraboloids of the same focal ratios. Combined with fast f/4 (8", 10") or f/5 (6") optics, the standard-equipment Super Plössl 26mm eyepiece yields an actual field in excess of 1.3°, for brilliant, rich-field imaging of nebulae, galaxies, and star clusters. High-power lunar and planetary images reveal subtle detail often lost in telescopes of lesser optical resolution. The optics are mounted in machined aluminum cells fitted to white-enameled metal tubes; each tube accepts the giant Meade rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces.



The Meade Schmidt-Newtonian Optical System.

LXD55 Equatorial Mount: Designed by Meade engineers and manufactured of machined aluminum for high-performance photo-visual observing, the new Meade LXD55 mounting moves effortlessly across the skies in either tracking or automatic GO TO modes. Included is an illuminated polar viewfinder for quick, precise polar alignment.

All LXD55 telescopes include an illuminated polar alignment finder as standard equipment.

Autostar Dual-Axis Electronic Control System: A revelation of advanced electronic and software design, the exclusive patent-pending Meade Autostar system, included as standard equipment with every LXD55 telescope, permits an amazing range of capabilities never before offered on telescopes in this price and aperture class:

Automatic GO TO capability at 4.5°/second on both axes simultaneously, to 30,223 database objects, including:

13,235 deep-sky objects — galaxies; diffuse and planetary nebulae; star clusters; the complete Messier, Caldwell, IC, and NGC catalogs.

16,888 stars sorted by name, SAO catalog numbers, double and variable stars.

50 objects in the Solar System; 8 major planets from Mercury to Pluto; the Moon; 26 asteroids; 15 comets.

50 Earth satellites; 200 memory locations for user-defined objects.

Automatic GO TO capability to any object of known R.A. and Declination.

Nine selectable slew and slow-motion speeds: 4.5°, 3°, and 1.5°/sec, 128x, 64x, 16x, 8x, 2x, and 1x sidereal.

Automatic sidereal-rate tracking in R.A. keeps objects precisely centered in the field.

Control of the telescope through your PC and full upgradability over the Internet, using the RS-232 serial interface. (Requires optional #505 Connector Set.)

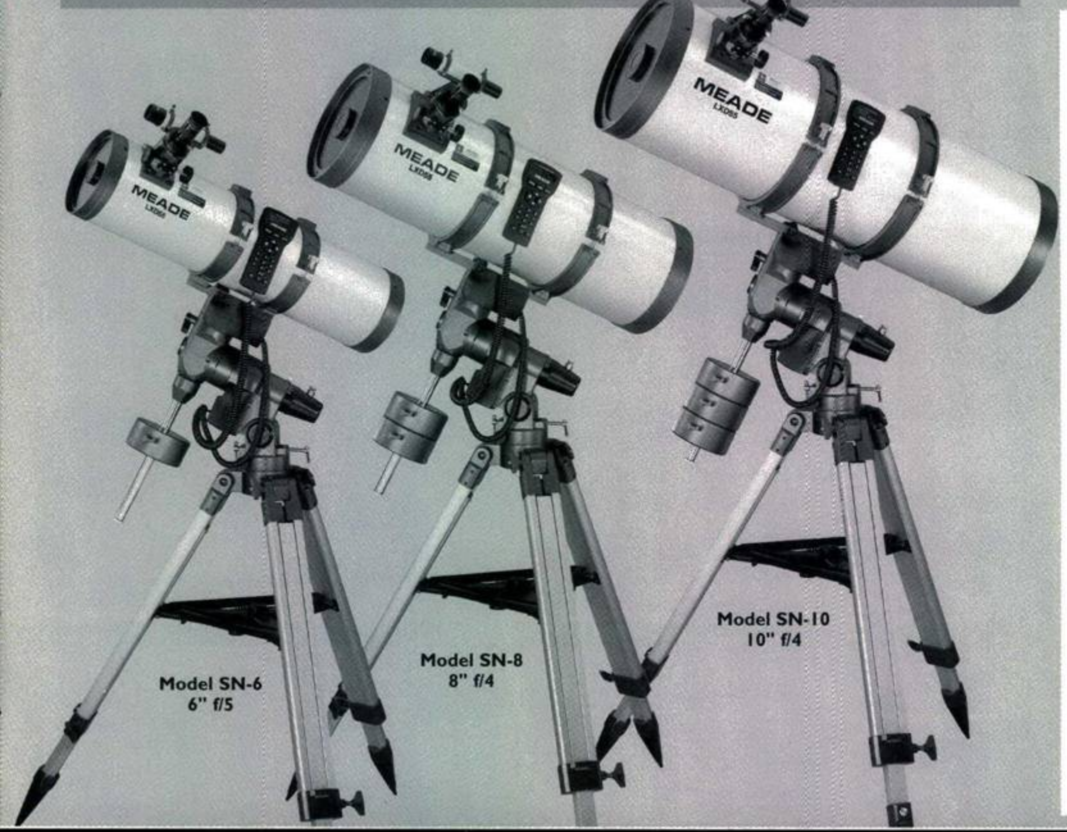
Battery Pack (12vDC): Included with each LXD55 telescope; rests on the telescope's accessory shelf and plugs into the control panel. The battery pack accepts eight (user-supplied) D-cell batteries, which power the telescope for more than 40 hours.

Astrophotography and CCD imaging: Armed with their fast photographic speeds, Meade LXD55 Schmidt-Newtonians are ideally suited for deep-space astrophotography and CCD imaging at the telescope's prime focus.

HBX
12vDC
ON - OFF
AUX
DEC

The LXD55 control panel is located below the upper bearing of the polar axis.

***Below, left to right:* Meade 6" f/5, 8" f/4, and 10" f/4 LXD55-Series Schmidt-Newtonian telescopes.** Each telescope is shipped complete with all equipment shown.



Meade LXD55 Schmidt-Newtonians open up the skies to images and capabilities previously unavailable in telescopes of their aperture and price level. Consider what a Meade LXD55 telescope can do for your observing program:

6" Model SN-6 — Observe ***hundreds*** of galaxies, nebulae, and star clusters of all types ***your very first night out,*** and hundreds more the next night out, simply by pressing the Autostar GO TO pushbutton. Watch as the telescope moves effortlessly and automatically from major planet to asteroid to galaxy to nebula at 4.5°/second, placing every object in the center of the telescopic field. Study fine fault lines on the Moon, structural detail in Jupiter's cloud belts and Red Spot, the Cassini division in Saturn's rings, and much more.

8" Model SN-8 — With 78% more light-gathering power than the 6" model, the 8" SN-8 roughly triples the number of observable objects in deep-space and resolves extremely fine planetary detail as well: Jupiter's cloud belts are seen as a web of intricate discontinuities; transits and shadow transits of Jupiter's main satellites are observable; six of Saturn's satellites may be seen in revolution about the planet. Deep-space phenomena take on new character with the larger 8" aperture, as Autostar moves the telescope automatically from one spectacular object to the next. CCD images at the telescope's prime f/4 focus show a new level of resolution and detail after only a few minutes' exposure.

10" Model SN-10 — A quantum leap in image brightness and resolution, the 10" SN-10 provides for a lifetime of serious study in deep-space or within the Solar System. Use Autostar to take an automatic tour, on any given evening, of, say, the 200 brightest diffuse nebulae, spiral galaxies, and globular star clusters. Or, with Autostar's pushbutton electronic slow-motion controls, scan the surface of the Moon at high magnification. Let Autostar locate and center in the field the outer planets Uranus and Neptune, now visible as finite-sized orbs, or Pluto, at the telescope's very limit of observability. It is an uncommon observer who might outgrow the capabilities of the Meade 10" SN-10.

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Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each: **$79.95** (4.54)
32mm (52°); **40mm** (44°)	each: **99.95** (5.26)
56mm (52°; 2")	**199.95** (7.02)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes UHTC-coated (95%+ reflectivity) precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930**, each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels.

$16.95 (2.73)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces.

$49.95 (5.26)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. (Not for LX200GPS models.)

$149.95 (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

$79.95 (6.85)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 3000™ Plössls
50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm (*far right in photo*), an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm $79.95** (3.86)

#911B
#911N
#908B
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

Series 4000 Oxygen-III Filters
Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia. **99.95** (4.54)

#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **149.95** (5.26)

Vibration Isolation Pads

Designed by Meade engineers, these isolation pads reduce typical telescope-tripod vibration damping times to *less than one second.* A tremendous aid for both visual and photographic astronomy. Place one pad under each tripod leg. #895 Vibration Isolation Pads, per set of three:

$49.95 (6.85)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

$79.95 (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with **any** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces.

$149.95 (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7; or for visual applications with 1.25" or 2" eyepieces.

249.95 (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.)

15.00 (3.86)

#644
MEADE
FLIP-MIRROR SYSTEM

#647
MEADE
FLIP-MIRROR SYSTEM

#1209 Zero Image-Shift Microfocuser

Identical to the Microfocuser supplied with Meade LX200GPS telescopes, but provided with a separate hand-box for use with all other Meade SCT models (e.g. LX10, LX50, LX90, LX200) or for Schmidt-Cassegrains of other brands. Threads directly to the telescope's rear cell. Permits extremely precise focusing of the image during visual or photographic applications; during CCD applications maintains precise image centration on even the smallest CCD chips. Operates at four speeds, from extremely slow to fast; accepts both 2" and 1.25" eyepiece barrels. Requires 8 x AAA (user-supplied) batteries.

$249.95 (9.85)

Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $99!

Epoch 2000sk *(upper display at left):* Use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** Dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely. Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software: Enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet.

EPOCH 2000sk Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM for Windows 95, 98, 2000, NT, and XP **$99**

LX200 Interface Cable: for Meade LX200/LX200GPS operation by Epoch 2000sk. **25**

EPOCH 2000ip Image Processing Software: On CD-ROM for Windows 95, 98, 2000, NT, and XP **99**

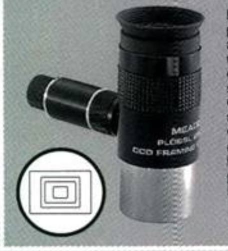
CCD f/3.3 CCD FOCAL REDUCER

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture.

$149.95 (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular



Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models; ST-4 through ST-8; AP1, AP2; and others. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25".

$129.95 (4.54)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing.

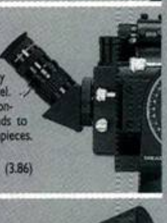
$49.95 (4.26)

#64 T-Adapter for ETX®

Threads to photo port of all ETX-90, ETX-105, and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera.

$34.95 (3.86)

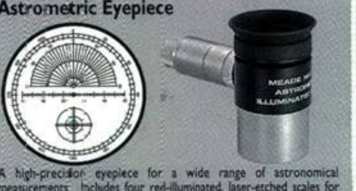
#932 45° Erecting Prism for ETX®



For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics.

$49.95 (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25".

$119.95 (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25".

$219.95 (6.38)

ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, optional eyepieces, erecting prism, table tripod, hand controller, etc. Includes steel latches & key.

#774 Case for ETX-90 models:
99.95 (8.58)

#776 Case for ETX-105EC:
99.95 (8.58)

#775 for ETX-125EC:
149.95 (13.38)

Dew Shields for ETX®

Threads into the front-lens cell and effectively inhibits the formation of dew on the lens surface.

#670 for ETX-60/70 . . . . **19.95**
#673 for ETX-90. . . . . . . **24.95**
#675 for ETX-105. . . . . . **27.95**
#678 for ETX-125. . . . . . **29.95**

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

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FOCUS CAMERA, Brooklyn, NY.
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OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
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RIVERS CAMERA, Dover, NH.
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Orders & Info.: 800-621-2248; IL: 847-367-4600.

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The most advanced Autoguider/Imager in its price class. For many, all the CCD imager required for a wide range of lunar, planetary, or deep-space applications. Includes the same "point-and-shoot" simplicity of larger Pictor models. Produces smooth, natural 16-bit images of all celestial subjects. Also a precision autoguider during astrophotgraphy.

$695. (12.00)

ETX® Deluxe Field Tripod

#884: Constructed of strong, lightweight steel; designed specifically for ETX-90, ETX-105, and ETX-125 Astro Telescopes. Tripod height adjusts from 25" to 43", for seated or standing observations. Graduated scale for elevation angle from 20° to 90° permits precise polar alignment of the telescope for astronomical applications. Tripod tilts and locks at 90° for terrestrial applications or for altazimuth use with Autostar. Telescope attaches to tripod in seconds with 2 thumbscrews. **Includes custom-fitted carry bag *(shown)* with pocket for accessories.**

$199.95 (10.00)

ETX® Carry Bag

Soft-padded Cordura-type carry bag with shoulder strap; permits storage of any 90mm ETX model, plus table tripod legs, eyepieces, other accessories.

$36.95 (5.26)

Electric Focusers for ETX®

Meade-engineered for smooth, rapid focusing with ETX-90, -105, or -125. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus through the telescope's Electronic Controller (EC) or through Autostar.

#1244 Electric Focuser for all ETX-90 and ETX-105 models:
$119.95 (6.85)

#1247 Electric Focuser for ETX-125 models:
$119.95 (6.85)

Advanced Field Tripod for ETX-125

#887: Yields *rock-solid* stability for sensitive applications of the ETX-125, even at high magnifications. **Includes fixed-height tripod convenient for standing observations, equatorial wedge with alignment controls in azimuth and latitude angle, and #889 Tripod Adapter for ETX-125.** Permits either altazimuth or equatorial orientation of the telescope for astronomical or terrestrial observing. Tripod legs are 2"-diameter chromed steel. For field use the tripod collapses for easy transport.

$349.95 (14.00)

#889 Adapter: Available separately, permits attachment of ETX-125 to any Meade LX10 or LX200 Field Tripod or wedge. **$69.95** (7.70)

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sky Gem

Bubbling Cauldron of Fire

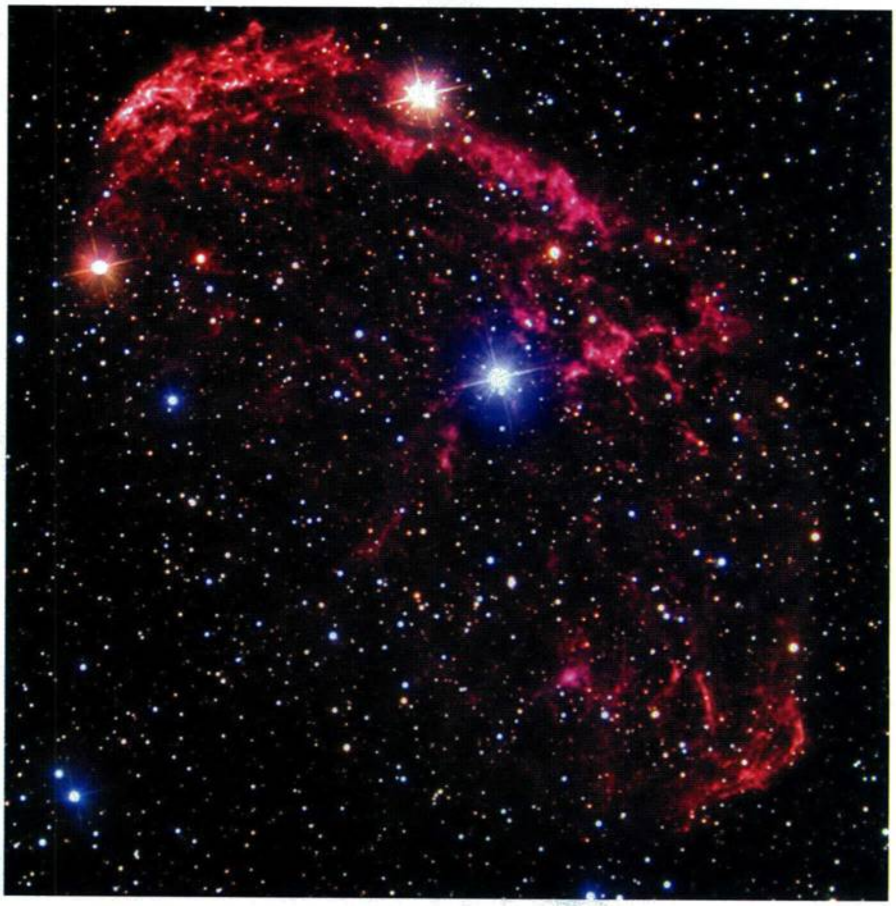
The Hubble Space Telescope's mosaic of the Orion Nebula (M42) reveals in stark detail the churning of infant suns as they emerge from clouds of hydrogen gas. Intense radiation surrounding the nebula's central Trapezium cluster carves out the unusual shape.

NASA/STScI

Amateur Astrophotos

I was very pleased to see the cover image and article about the amazing work that Rob Gendler is doing with CCD imaging from his driveway ("Imaging from the 'Burbs," March 2002.) I am new to CCD imaging, and his work is what I want to emulate. I don't think there is anyone better at bringing out the beauty of deep-sky objects. I recently contacted him, and he was gracious enough to allow me to visit him. Needless to say, I was quite impressed by his equipment and abilities, especially in image processing. But I was even more impressed by his hospitality and willingness to take the time to help a newcomer. Rob Gendler epitomizes the true spirit of the amateur, even though I feel that his astroimaging work qualifies as professional. — *Thomas L. Haynes, Rockford, Michigan*

I've been an *Astronomy* subscriber for many years and enjoy most articles. But I was disappointed in March's cover story ("Imaging from the 'Burbs"). After seeing the enticing cover photo and headline, I was surprised to find a brief article about one photographer's ability to capture astrophotos from the suburbs. The story did not offer any suggestions on how others can take similar photos. The images were beautiful, but I found the cover misleading and the article disappointing. — *Dan Lafferty, Collegeville, Pennsylvania*


Rob Gendler captured NGC 6888, sparkling in Cygnus, from his driveway. Robert Gendler

Planetary mysteries

I have always been fascinated with ringed planets. What concerns me is that ideas about the creation of the rings around the giant planets seem to be illogical. Much current theory contends that rings were formed by dust particles kicked up by impacts with moons, as with Jupiter's rings, or by the destruction of moons, as with Saturn's rings. But why is it that all the gas giants had moons destroyed by various impacts, causing rings, but none of the inner planets did? Isn't it more logical to assume that the rings around the giant planets are the remnants of the gas and particles from which they and their moons originally formed? Given that it is also widely held that these planets developed later than the inner ones, it makes sense that the process hasn't quite finished, and what we are actually seeing are the final stages of a developing planet. — *Greg Fogarty, Windsor, Queensland, Australia*

Planetary rings can be thought of as coming in two broad categories, those composed of only microscopic particles, and those composed of particles whose sizes are measured in centimeters or meters. The former "dust" rings are present around all four of the giant planets, while only Saturn and to a lesser degree Uranus possess substantial rings with macroscopic particles.

So why do we say that the rings are probably relatively young? A variety of factors contribute to the evolution of rings, including gravitational interactions of the rings with the parent planet and its satellites, collisions between ring particles, meteoroid bombardment, electromagnetic forces arising from interactions with the planet's magnetic field, and radiation pressure from incident sunlight. However, the last two are really only significant for microscopic ring particles.

Generally, for dust rings, the combination of forces will act to remove the fine particles in relatively short periods of time. The current "best" idea is that impacts,

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primarily by micrometeoroids and the ring particles themselves, on small embedded satellites (parent objects) produce the necessary replacement material. With adequate sources of new material, planets may be able to sustain dusty rings for long periods of time — perhaps even for the age of the solar system.

So why do all of the jovian planets have rings while none of the terrestrial planets do? Several factors are probably at work. The first is location; terrestrial planets are close to the sun and far from the source of comets. The electromagnetic and solar radiation environment in the inner region of the solar system is hostile to the maintenance of dust. Distance from the source of short period comets and the much weaker force of gravity associated with terrestrial planets means that the capture and break up of a large cometary body is much less likely than for any of the jovian planets. Finally, of the terrestrial planets, only Mars has small satellites, while all of the rings we do see seem to be associated with large families of small satellites.

Astronomers have been searching for the answers to the questions concerning the age and origin of the rings for at least two centuries. We're getting there, but we still have a long way to go. — Mitch Gordon, NASA Ames Research Center

Tomorrow's skies

Thank you for the March 2002 Behind the Scenes. Editor Bonnie Gordon touched on many themes of concern to me, such as showing Orion to my great-grandchildren, and the contrasts between peaceful and war-torn Afghanistan, as well as between that country's clear skies of today and what they could become in the future. The story was beautiful, written with all the joy, pathos, and humor it deserves. The conclusion gave hope for the future of Afghanistan and the rest of the world. — *Florence B. Woods, Bath, New Hampshire* ▣

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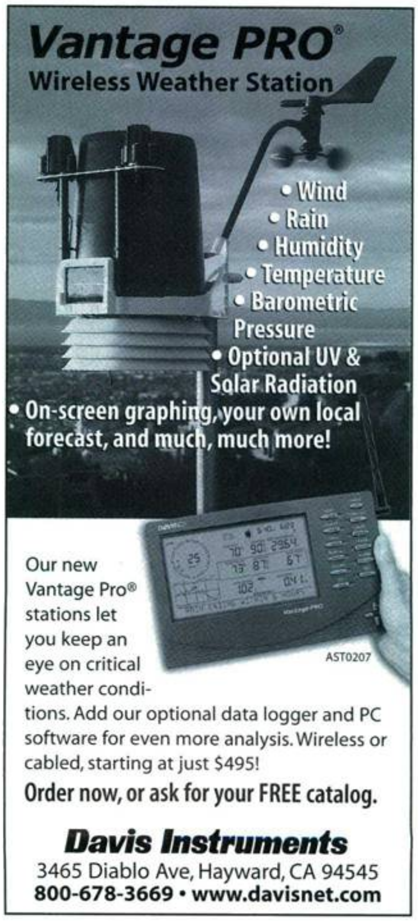

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40mm, 2"	234.95

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BUSHNELL

Compact 4.5" Reflector

$129.95

Features a unique cradle mount which is convenient to use and transport. A wide field of view makes it easy to locate objects and keep them in view
- Aperture: 4.5"
- Focal Length: 400mm
- Eyepieces: 1.25" 4mm (100X), and 25mm (16x)
- Focuser: Precision Rack & Pinion, Tripod adaptable, includes convenient shoulder strap

BINOCULARS

PROOPTIC

These binoculars with their large objectives high quality BAK-4 prisms will provide you with breathtaking wide-field observation of astronomical objects as well as terrestrial viewing under low light conditions.

Each binocular is provided with a high quality Hard Case, Neck Straps and Rubber Eye-Cups.

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Fully Multi-Coated Series

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As Written Up In Sky & Telescope June 2000

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$495 ($545 w/UHTC)
Meade ETX-105EC
$695 ($770 w/UHTC)
Meade ETX-125EC
$895 ($990 w/UHTC)
#497 Autostar **$149**

ETX-125EC

Hardly a day goes by that we don't get a note or E-mail message like the one reprinted on the next page, or a call that goes something like this: "Your ads are right. Dealer so and so advertises low prices – but they don't have what I want in stock, they couldn't answer *any* of my questions, and they wanted my credit card number before they'd even *talk* to me. They said if I wanted to ask questions, I should call the manufacturer . . . and then they hung up on me!"

If you want the right telescope, you need more than a camera store clerk armed with only a price list and a puzzled look when you ask questions.

What you *really* need are people who take the time to listen to what *you* need, people who answer your questions truthfully, people with years of experience using and selling telescopes who help you get the most telescope for your dollar. That's exactly the kind of people you'll find at ***astronomics***.

Unlike camera stores and shopping mall gift shops, telescopes are our specialty at ***astronomics***, not just a sideline. We're a family-owned full-line telescope dealer – not just a few toy telescopes stuck off in the corner of some no-help department store, toy store, or gift shop as an afterthought. And, unlike department store clerks, we don't work on commission, so we won't try to sell you more than you need just to pad our paychecks.

We've been helping people choose the right telescope since 1979. We have the experience to help *you* pick the scope that fits your needs . . . *and your budget* . . . from the many Meade, Celestron, TeleVue, Takahashi, and Questar telescopes we stock at discount prices from $99 to $27,995.

And we can usually ship your right telescope right away, since we have over 1000 telescopes in stock!

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Losmandy G-11

If you're looking for a premium quality German equatorial mount, look no further than the Losmandy GM-8 and G-11 mounts we stock. They have adjustable height tripods and dual axis drives with PEC drive correctors. There are optional adapters available to fit virtually any catadioptric or refractor optical tube, plus the Losmandy accessories to customize the mount to your heart's content. We even stock go-to mounts and Gemini go-to retrofit kits.

TMB triplet apos!

TMB 100

Dozens of TMB refractors are in the hands of some very delighted customers of ours, and the buzz about them grows and grows. Visit our website to see the scopes that are the talk of experienced astronomers everywhere.

TMB 80/6 80mm (3.1") f/6	$\$1690^{00}$
TMB 80/7 80mm (3.1") f/7	1690^{00}
TMB 100 100mm (4") f/8	3290^{00}
TMB 105 105mm (4.1") f/6.2	3290^{00}
TMB 152 152mm (6") f/7.9	6990^{00}
TMB 175 175mm (7") f/8	$11{,}990^{00}$
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Custom-built Dobs.

Astronomics offers custom-made truss tube Dobsonians hand-crafted by Pete Kron, a long-time Astronomics customer who is now a full-time member of our staff. Pete has been custom-building Dobs for over 15 years, in sizes up to a 36" f/5, and is known for using premium quality components. While Pete specializes in 18" through 24" apertures, custom mirror sizes and focal ratios are also available. He can also upgrade your unwieldy commercially-made Sonotube Dobsonian to an easily transportable truss tube version.

Prices start at $3500 for a custom-built 18" scope. Converting your commercially-made Sonotube Dob optics to a truss tube mount starts at $1500 for a 16" f/4.5 scope.

For more information, or to discuss specific pricing, contact Pete via e-mail care of questions@astronomics.com. You can also reach him by phone toll-free from 9 to 5 Monday through Friday at (800) 422-7876.

The Meade LXD55 makes ordinary reflectors and refractors obsolete.

Meade 5" LXD55 refractor
$695

Why pay for an ordinary equatorial mount refractor or reflector when you can get a fully computerized Meade LXD55 for the same price? The go-to capability of the LXD55 series is the most significant advance in an affordable German equatorial mount since the mount was invented in the early 1800s!

You won't spend your time hunting for faint deep space objects with a 5" or 6" LXD55 achromatic refractor or a fast focal ratio Schmidt-Newtonian 6" to 10" reflector (either with standard or UHTC optics). A few touches on the keypad of the built-in Autostar computer sends your scope speeding to any of the more than 30,000 stars and objects in its memory, centers the object, and tracks it as you observe. You'll spend more time looking *at* deep space objects and planets and less time looking *for* them with an LXD55.

Each is complete with adjustable height tripod, motor drives, accessory tray, finderscope, eyepiece, and Autostar computer. Order now and get your German equatorial observing out of the dark ages.

$729
Meade 8" LXD55 f/4 reflector
($854 w/UHTC)

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We have all TeleVue scopes in stock. Standard packages include eyepiece, diagonal, tube ring. Just look at this selection . . .

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TV-102, standard package	2635^{00}
TV-102, optical tube only	2200^{00}
TV-85, standard package	2080^{00}
TV-85, optical tube only	1680^{00}
TV-76, standard package	1675^{00}
TV-76, optical tube only	1275^{00}
Pronto, standard package	1120^{00}
Pronto, optical tube only	775^{00}
Ranger, standard package	695^{00}
Ranger, optical tube only	570^{00}

NP-101 **$3385**

TV-85 **$2080**

Whether it's the newest telescope or the newest eyepiece (like the 3mm to 6mm Nagler zoom at $380), if it's from TeleVue, the chances are good we have it in stock. Gibraltar, Panoramic, and TelePod mounts; Nagler, Radian, Panoptic, and Plössl eyepieces; Powermates and Barlows; red dot finders; Everbrite diagonals; and more – we have it all. We're TeleVue specialists, and we stock TeleVue in depth. Call us and see.

Fuji astro binoculars!

Comet Hyakutake, among others, was discovered using 150mm Fujinon binoculars. We can't guarantee *you* will discover a comet with a 10 x 70mm or 16 x 70mm Fujinon FMT-SX binocular, but we can guarantee that the 70mm Fujinons are built to the same premium optical quality standards as the big Fujis. For pricing and full specifications, see our informative website at **www.astronomics.com**.

We stock Pentax XL eyepieces from $\$227^{\underline{50}}$.

From 5.2mm to 40mm, we stock all the Pentax wide field (55° to 65°) XL eyepieces. Each has a rotate-to-adjust-the-eye-relief eyecup, ED glass, and a long 20mm eye relief that's perfect for those who wear eyeglasses.

5mm 1.25"	$\$244^{50}$
7mm 1.25"	237^{50}
10.5, 14, 21, or 28mm 1.25"	227^{50}
40mm 2"	244^{50}
8-24mm zoom 1.25"	379^{00}

The Stellarvue refractor, "Hot New Product of 2001."

The 80mm f/6 **Stellarvue AT1010** was named a "Hot New Product of 2001" in the December 2001 *Sky & Telescope*. Independent reviews say it competes favorably with ED scopes that cost twice its modest price, and easily outperforms imported achromats in color correction and resolution. The AT1010A has hand-assembled/triple tested optics, tube rings, tripod adapter, 2" focuser with both 1.25" adapter and T-threads , red dot finder, oversize rubberized focus knobs for easier use in cold weather, and a soft padded carry case. It's in stock to ship now.

AT1010A $\$499^{95}$
shown w/optional diagonal and eyepiece

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We carry the **Lumicon** Deep Sky, UHC, Oxygen III, and H-Beta filters in 1.25", 2", and rear cell versions for SCT use. We also have two-filter Lumicon sets in various combinations at money-saving package prices.

We carry the **Meade** broadband, narrowband, and Oxygen III filters in 1.25", 2", and rear cell versions for SCT use.

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Why wait? We'll ship either Meade LX90 from stock.

Meade
8" LX90
$1695

The 8" **Meade LX90** Schmidt-Cassegrains let you live the good life of big-aperture go-to astronomy for not a lot of money. They're available from stock with either standard or UHTC optics.

The LX90 with standard optics is only $1695. The LX90 with UHTC optics (with up to 20% brighter images) is only $1870. Both have a heavy-duty adjustable height tripod, an Autostar go-to 30,223 star and object computer, a big 8 x 50mm finderscope, and a 26mm Super Plössl eyepiece.

We usually have several dozen of both LX90s in stock at all times, so the chances are good you can get *your* LX90 with little or no delay. If Meade is shipping either LX90 *(or any Meade scope)* for a dealer to keep in stock, the chances are very good that we *have* it in stock.

Meade prices are about the same anywhere you call. So why order a Meade scope or accessory from a dealer who charges your credit card, then makes you wait and wait until he finally gets around to ordering what you want? Not when you can usually get the Meade scope you want . . . right now . . . at the right price . . . right here at ***astronomics.***

8" and 10" Meade GPS UHTC scopes ship from stock. They do all of the work so you can see 20% more.

Meade
8" LX200
GPS
with
UHTC
$2670

Never before have so many features been packed into one telescope series. The new LX200GPS scopes – the widest variety of premium go-to telescopes on Earth – have all the features you've dreamed about since you started astronomy – plus optional UHTC (Ultra High Transmission Coatings) for up to 20% brighter images.

You get fully automatic GPS alignment with true north and true level sensors and automatic magnetic declination correction; a unique mirror lock to eliminate image shift during critical CCD imaging; a standard equipment 4-speed electric focuser; a built-in computer database of over 145,000 stars and objects; flashlight battery operation; and much more.

Meade GPS scopes with UHTC optics will let you see up to 20% *more.* Plus, you'll spend more time looking *at* celestial objects and less time looking *for* them. We had 39 8" and 10" LX200GPS scopes with UHTC in stock as this was written. Chances are good we have one in stock for you.

An ETX-90 case, $\$74^{95}$!

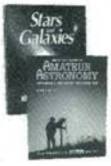
The 8" x 15.5" x 18.5" JMI hard case fits the ETX-90RA and the ETX-90EC. Its high density foam interior is diecut to hold scope, four eyepieces, tabletop tripod, T-adapter, and more. Whether for storage or travel, this hard case is a great buy. Regularly $99.95, we have less than 50 still available at this low sale price that saves you 25%.

We also have cases available for the Meade LX90 and 8" through 12" LX200GPS, and the Celestron NexStar 4/5/8 and 8/11 GPS.

Canon image-stabilized binoculars . . . lower prices and rebates, too!

"Truly a quantum leap in binocular observing . . . particularly impressive was how well these binoculars compared to much larger apertures . . ." is what *Sky & Telescope* said about the Canon image-stabilized binoculars. There are no jittery images while hand-holding these binos, just rock-solid observing that reveals more detail than conventional binoculars. From a tiny 8 x 25mm for travel and birding to a big 18 x 50mm for astronomy, there's an image-stabilized Canon that's right for you. There are new lower prices from Canon and *$50 to $100 rebates.* Full details on our website.

Half-price sale on observing books!



We bought almost 4000 beginning and advanced deep space observing books at some very special prices. We're passing our savings on to you, pricing them as low as 50% off retail. Take a look . . .

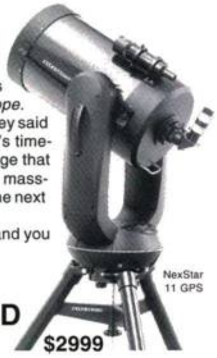
Beginner's Guide to Amateur Astronomy 166 page soft cover, a great way to start, reg. $14.95	$\$9^{95}$
Galaxies & The Universe 112 page soft cover, helps you find 100s of galaxies, reg. $19.95	$\$9^{95}$
Stars & Galaxies 200 page hard cover, observe 344 of the best deep sky objects, reg. $29.95	$\$14^{95}$
Universe From Your Backyard 188 page hard cover, observe 690 deep sky objects, reg. $29.95	$\$14^{95}$

The best CCD book.

Before you spend $3000 on a CCD camera, spend $49.95 on this book.

Ron Wodaski's **The New CCD Astronomy** is simply the best reference book available about CCD imaging for the beginning to intermediate CCD astrophotographer. This is the one CCD reference book to own. *Period.*

The rave review multicoated NexStar 11 can be yours in a week.



Celestron's 11" go-to computerized scope with multicoated optics – the **NexStar 11 GPS** – got a *rave* review in February's *Sky & Telescope*. The review gave it "an enthusiastic two thumbs up and a gold star." They said it has "Brains and good looks. The NexStar 11 GPS puts Celestron's time-tested 11-inch f/10 Schmidt-Cassegrain optics in a sleek new package that includes some of the most advanced electronics ever offered in a mass-produced telescope . . . Celestron is the first to take Go To scopes to the next step in their evolution, and it's a nice step indeed."

We have the NexStar 11 in stock (16 as this was written). Call us and you can be observing with yours in about a week.

The NexStar 8 GPS is multicoated for both CCD and visual observing.

NexStar 8 GPS $2499

The in-stock 8" **NexStar 8 GPS** (20 on hand as this was written) has multicoated Fastar-compatible optics for wide field CCD imaging. The NexStar 8 GPS easily converts to an astonishingly fast f/1.9 focal ratio for CCD use. With an optional Fastar lens assembly and a $1295 SBIG ST-237A CCD camera, the NexStar 8 GPS will record a huge 32 x 42 arc minute field. That's larger than the full Moon and more than three times the sky area imaged by a $7695 camera on a similar 8" scope without Fastar optics! Of all computerized GPS scopes, *only the Celestron NexStars have multicoated Fastar-compatible optics!*

Eyepiece storage cases from $\$2^{49}$.

Bolt-type containers protect eyepieces dew and dust. Foam inserts cradle eyepieces to protect them from accidents. Our website tells which eyepieces fit which containers (including some other containers not listed below).

42mm x 60mm Holds most Celestron NexStar, Meade Series 3000, and TeleVue Plössls, etc.	$\$2^{49}$
52mm x 80mm Holds TeleVue Radians, Nagler Type 6, most Barlows, large Celestron Ultima, etc.	$\$3^{49}$
65mm x 80mm Holds most illuminated reticles, 22mm Panoptic, 12mm Nagler, etc.	$\$3^{99}$

Compare Celestron go-to prices. Only $1499 for an 8" . . .

NexStar
8
$1499

Compare the price of the **Celestron NexStar 8** go-to SCT with other 8" go-to scopes. At only $1499 – complete with adjustable height tripod, Starbright multicoated high transmission optics, red dot finder, 40mm Plössl eyepiece, and a computer with 18,000+ objects in its memory – it's priced hundreds of dollars less than other 8" go-tos. It's enough scope to keep you observing for the rest of your life, at a price that puts 8" go-to astronomy within the reach of practically everyone!

$1149 for a 5" . . .

NexStar 5
CELESTRON

You get a $149 value adjustable height aluminum tripod (with built-in equatorial wedge) and a computer control *for free* when you buy a **Celestron NexStar 5** go-to Schmidt-Cassegrain. Compare this $1149 price – *complete* – with other 5" go-to scopes that charge extra for an optional tripod and computer and you'll see that Celestron saves you *nearly $100!* NASA uses 5" Celestron optics on the Space Shuttle. Don't your eyes deserve the same quality image?

$1149

Sell your used telescopes and accessories quickly by using the classified ads you can run *for free* at

www.astrofieds.com

A $450 bino for only $\$179^{95}$? One couple bought 9!

Free $7.95 Nikon lens cleaning pen with purchase

One couple liked the two $450 list Celestron/Tasco 8 x 42mm roof prism binos they bought from us so much that they bought seven more to give to their kids and their spouses. At this low price, they're a steal!

Armored, waterproof, multicoated, BaK4 prisms, soft case, wide neck strap, 6.6° field, 16mm eye relief, and a ***No-Fault*** lifetime warranty! If your bino ever breaks, *even if you drop it,* send it to Tasco with $10 for handling and it will be repaired or replaced for free!

Discovery Dobsonian reflectors start at only $349.

6" f/8 DHQ, shown with optional eyepiece rack
$349

Why settle for an imported Dob when you can have made-in-the-USA quality *for less money!* Discovery doesn't use imported, mass-produced optics that are merely spot-checked to see if they're acceptable. Discovery optics are made in California by optical craftsmen, one quality mirror at a time. Each is hand figured to diffraction-limited performance, and it doesn't leave the Discovery optical shop until it's right.

Each DHQ series Dob has an adjustable metal primary mirror cell, a true *thin vane* adjustable 4-vane diagonal mirror spider, *two* Plössl eyepieces, a built-in tube balancing system, a tube carry handle, new oversized bearings, a 6 x 30mm finder, and a dust cover. You can get an upgrade kit that adds two more Plössl eyepieces, an eyepiece rack, a second dust cover, and a Moon filter for only $49 more!

Premium Dobs from 10" to 17.5" in aperture are also available. And for those who need big aperture portability, truss-tube Dobs are available in apertures from 12" to 24". Here are the Discovery 6" to 10" DHQ Dob prices:

6" f/5 Discovery DHQ	$\$349^{00}$, plus $39 freight
6" f/8 Discovery DHQ	$\$349^{00}$, plus $39 freight
8" f/6 Discovery DHQ	$\$449^{00}$, plus $49 freight
8" f/7 Discovery DHQ	$\$449^{00}$, plus $49 freight
10" f/4.5 Discovery DHQ	$\$649^{00}$, plus $69 freight
10" f/5.6 Discovery DHQ	$\$649^{00}$, plus $69 freight

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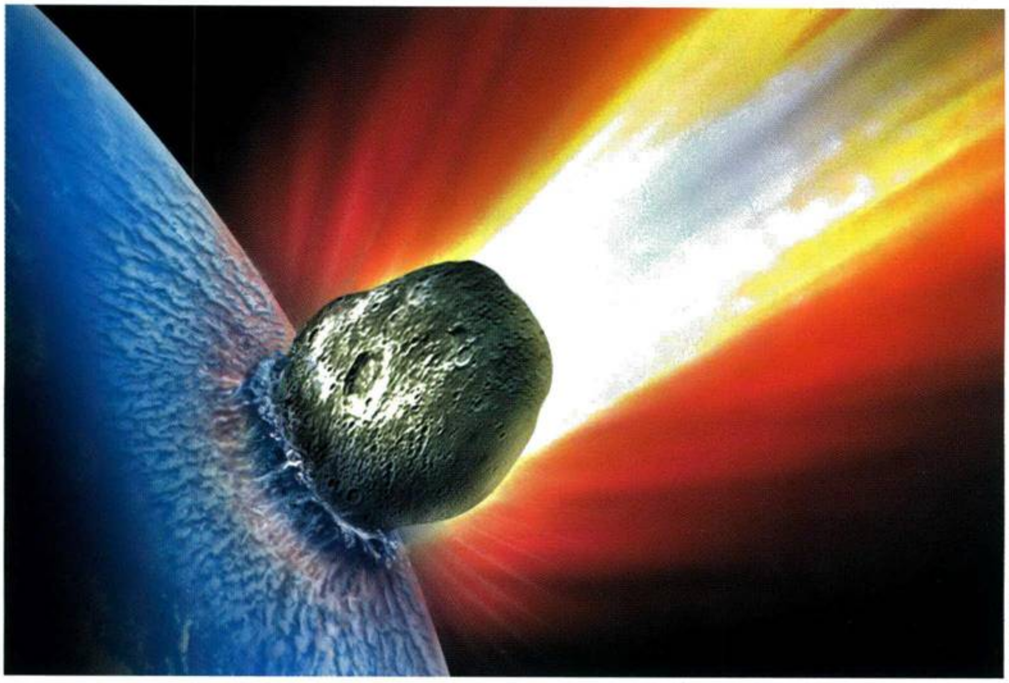


Astronomy: Elisabeth Rowan

▶ Of all the reports in recent years about possible asteroid or comet impacts, one published in *Science* magazine this April stands out for having by far the highest likelihood of a collision found to date: a 1-in-300 shot. And with a diameter of 0.7 mile (1.1 km), the asteroid 1950 DA could cause global devastation if it does strike Earth. Yet the impact date remains so far off (there is no possibility of it hitting before March 16, 2880) that not only are astronomers not worried, but the find may even prove a scientific bonanza — and a threat that contains the seeds of its own solution.

The most amazing aspect of this forecast, made by a 14-member team led by Jon Giorgini of NASA's Jet Propulsion Laboratory, is that such a long-term prediction was possible at all. With most near-Earth asteroids, the uncertainties build up over time so that meaningful forecasts can't be made more than about a century ahead.

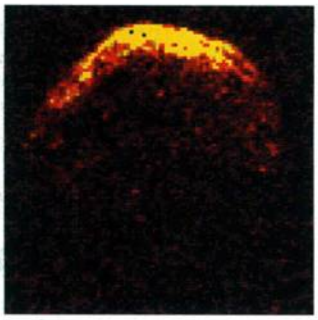
But with asteroid 1950 DA, several factors help to pin down its future path. First, as its name indicates, it was discovered more than a half-century ago, providing a longer-than-usual baseline of observations. Second, its orbit is inclined to the ecliptic, reducing the number of perturbing encounters with planets and other asteroids. And finally, it has a never-before-seen kind of gravitational resonance that tends to force it back toward its original orbit anytime a perturbation tugs it one way or the other.

There's another unusual twist to the story of this possible doomsday asteroid: The greatest uncertainty in its future motion comes from the way it reradiates absorbed solar radiation, an obscure phenomenon called the Yarkovsky effect. This arises because energy absorbed on the sunward side radiates away on the dark side, imparting a tiny momentum to the asteroid that depends on its exact spin rate and orientation, composition, and even surface color — none of which are known.

The bad news is that this means it may be impossible to improve estimates of the impact odds until very near the encounter date, although close-up examination by spacecraft could help. The good news is that the same effect might be harnessed someday to gently nudge this or any other asteroid aside if it does turn out to be on a collision course.

According to a study by University of Arizona planetary scientist Joseph Spitale, simply altering the surface reflectivity, for example by dropping white chalk or black carbon powder on the surface or using a huge reflective Mylar sheet to wrap the asteroid like a giant baked potato in aluminum foil, could be enough to change its path (though it might take centuries).

The prospect of using a silvery coating to save us from destruction may be the silver lining in this potentially threatening discovery. — DAVID L. CHANDLER

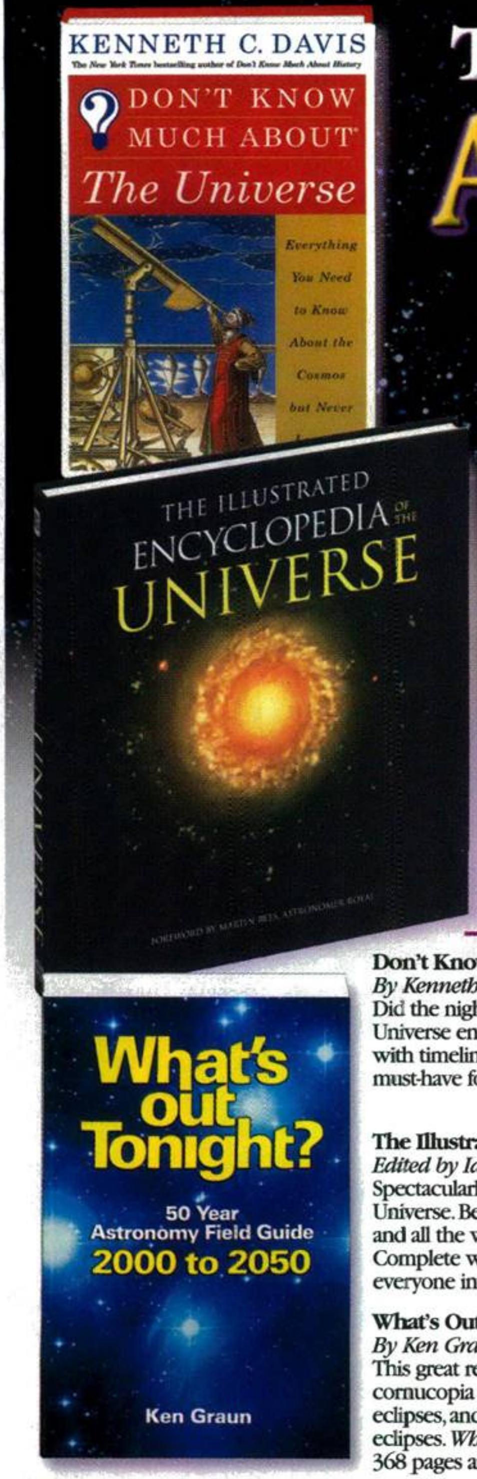


Radar reveals the menacing asteroid 1950 DA. Steven Ostro (JPL)

QUARK STARS

Strange Stars; New Matter?

▶ Astronomers using the Chandra X-ray Observatory have examined two weird objects that should look like neutron stars, but don't. They appear to be incredibly dense — too dense even for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Publisher's Price $26.00

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What's Out Tonight?
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Astronomy Magazine July '02 U803/RS138/32

neutron stars. The objects apparently consist of a new type of matter made simply of quarks, the most basic subatomic particles known.

A team of scientists headed by Jeremy Drake of the Harvard-Smithsonian Center for Astrophysics studied RX J1856.5–3754, a suspected neutron star in the southern constellation Corona Australis. Although it has the mass of a neutron star, the researchers found the object to be only about 7 miles (11.3 km) across.

"That number is uncomfortably small," said Drake at an April 10 press conference. The diameter is so small, in fact, that standard neutron-star models fail to explain it.

Another team, which includes David Helfand of Columbia University and colleagues at Harvard-Smithsonian, used Chandra to study the pulsar at the center of 3C 58, a supernova remnant in Cassiopeia born in a stellar explosion witnessed by Chinese and Japanese astronomers in 1181. Surprisingly, the object glows at a temperature of less than a million degrees Celsius — much too cold according to the cooling rates expected for neutron stars.

The observations suggest that the two odd stars are even more compact than ultra-dense neutron stars. Their density, Helfand explained, would be similar to that of Earth if our entire planet were crammed into the auditorium at NASA Headquarters where the researchers presented their findings.

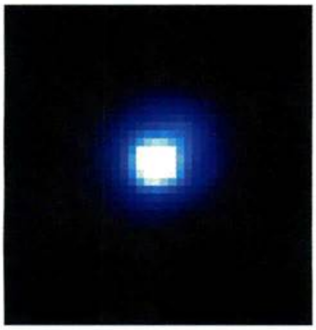
The scientists believe the fantastic density of these stars could be explained if they were composed not of neutrons, as previously thought, but of a new type of matter made entirely of quarks — the minuscule particles that compose protons and neutrons. Taking up less space than neutrons, quarks can be jammed together even more tightly, allowing the matter and the stars to become much more compact.

In the matter that makes up ourselves, our planet, and our solar system, quarks never break free from atomic nuclei. But these strange stars would be a giant soup of loose quarks.

"Nature has carried out an experiment that we can't yet conduct on Earth," commented University of Chicago astronomer Michael Turner.

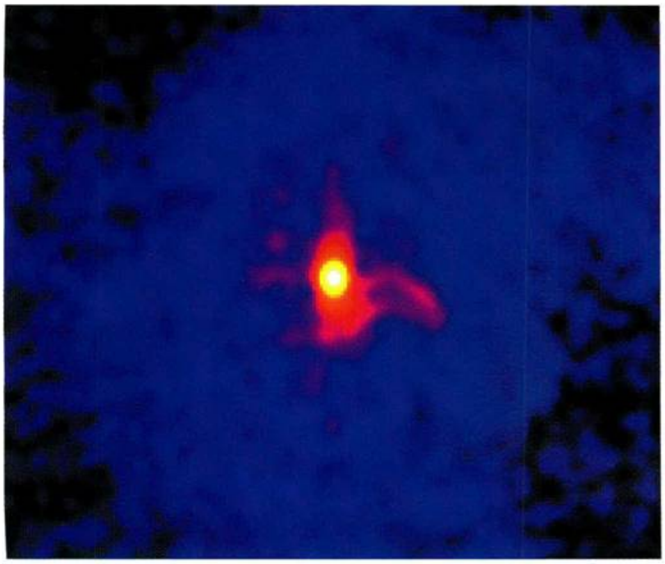
Theorists had postulated that such "quark stars" might exist, and astronomers had even identified a few suspects. But Chandra's observations of RX J1856 and 3C 58 are the first evidence to support the theory. "Other candidates are a lot less obvious," said Drake.

Both teams insist that further observations are needed to determine whether these stars are truly composed of this new quark



Left: RX J1856 appears too small to be a neutron star.

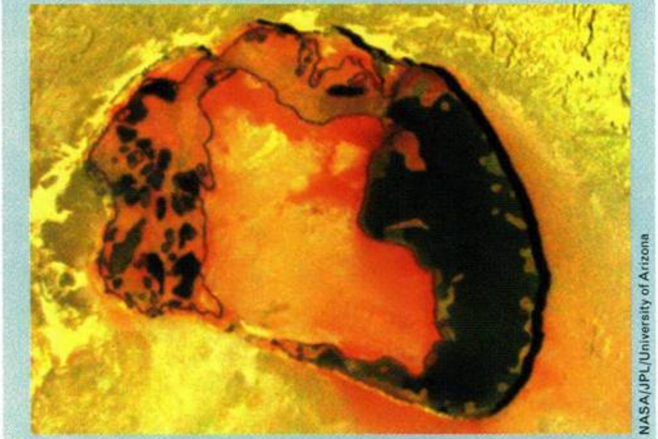
NASA/SAO/CXC/J. Drake et al.



Below: The pulsar in 3C 58 seems too cool to be a neutron star.

NASA/SAO/CXC/P. Slane et al.

GALILEO



NASA/JPL/University of Arizona

SUPERHEATED LAVA FILLS TUPAN PATERA, a fiery volcanic center on Jupiter's moon Io. The Galileo spacecraft captured this view of the cauldron in October 2001, during the probe's 32nd orbit of Jupiter. The colors have been enhanced slightly from what the eye would see; the red includes a small amount of infrared energy. The image reveals Tupan to be a volcanic caldera some 45 miles (75 km) across surrounded by cliffs that soar some 3,000 feet (900 meters) high. Dark material covers the eastern part of the caldera — the signature of recently erupted, still-hot lava. The "island" at the center of the image apparently sits on top of the lava lake. Planetary scientists think that the island's yellowish covering represents sulfur dioxide frost. Also note the patches of dark material that lie on the caldera's western side, most likely lava flowing onto a crusted-over part of the lava lake. The image has a resolution of about 440 feet (135 meters).

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matter. Drake points out that his group's observations of RX J1856 could be interpreted as a hot spot on the surface of a normal neutron star, but that the Chandra results do not show the pulses of x rays that would be expected if the spot were rotating around with the star. To rule out that possibility, he says, would require a lot more observing time on Chandra than the nearly six full days his team has already spent. In his opinion, the best chance to settle the question would be to find more of these strange objects. — VANESSA THOMAS

COSMOLOGY

Long Ago and Far Away

▶ To a generation of moviegoers, "A long time ago in a galaxy far, far away" ranks among the most memorable opening sequences in film history. In the *Star Wars* universe, that galaxy was the stage for a mythic battle between good and evil. In the real universe, astronomers search for ever more distant galaxies in a quest to understand how the infant cosmos evolved.

A recent discovery pushes the frontier of distant galaxies farther away than many astronomers once thought possible. "This recently discovered galaxy is forming stars at a time speculated to be in the 'Dark Ages' of the universe, when galaxies began to turn on," says Esther Hu of the University of Hawaii, who led the discovery team.

The galaxy, named HCM 6A, glows so faintly that the astronomers needed help to find it. The help came from a massive galaxy cluster known as Abell 370, which lies some 6 billion light-years from Earth in the constellation Cetus. The cluster's mass acts as a gravitational lens, brightening objects that lie behind it.

The researchers targeted the cluster as part of a survey with the 10-meter Keck II Telescope. Hoping to find background objects, they hit the jackpot with HCM 6A. With a redshift of 6.56 (meaning the expansion of the universe has shifted its light to longer wavelengths by 656 percent), the galaxy lies some 13.3 billion light-years from Earth. Even more impressive, that means we are seeing it as it was only about 800 million years after the Big Bang. The previous most-distant object, a quasar with a redshift of 6.28, lies some 50 million light-years closer.

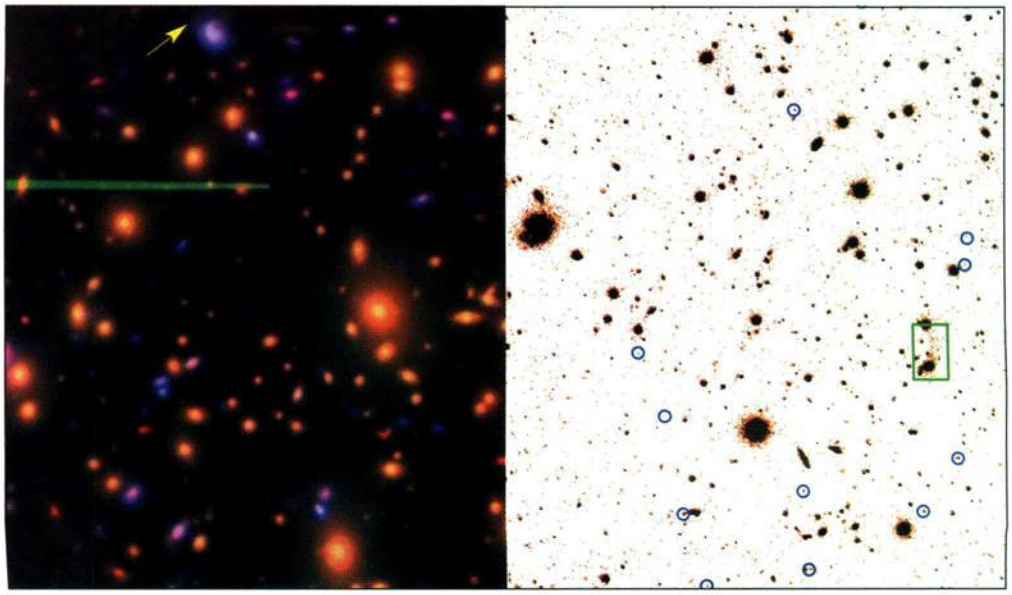
"The fact that this is a galaxy and not a quasar is also important," says team member Len Cowie of the University of Hawaii. "When the first galaxies form, it's like turning on lights to clear out a fog bank. Quasars are really bright though rare, so they can clear large cavities around themselves. That light from the fainter but much more numerous galaxies is getting out means that a significant amount of early star formation has already taken place, and much of the general fog has already dissipated."

Just how many stars are forming? During follow-up infrared observations made with the 8.3-meter Subaru Telescope, the astronomers were able to estimate that 40 times the mass of the sun is being turned into stars each year.

Not to be outdone — at least by very much — a different team of astronomers has discovered the most distant group of galaxies known. Using the European Southern Observatory's 8.2-meter Very Large Telescope (VLT), the researchers found at least 20 galaxies clustered together at a distance of some 12.6 billion light-years.

The team, led by George Miley of Leiden University in the Netherlands, targeted several distant radio galaxies, searching for galaxy groups in their vicinity. VLT observations of the most distant of these radio galaxies, TN J1338–1942 in Virgo, turned up 28 nearby galaxies. Follow-up observations have confirmed at least 20 of them lie at the same distance as the radio galaxy. The galaxy group spans more than 10 million light-years.

The group's existence means that galaxies must have started to form groups within the first 10 percent of the universe's history. The astronomers estimate that the total mass of the group must be about 1,000 trillion solar masses — comparable to the masses of nearby rich clusters of galaxies. For this group to eventually evolve into a rich cluster, its volume must contract by a factor of ten in about a billion years. — RICHARD TALCOTT



Left: The most distant galaxy known (arrow) lies behind Abell 370. Esther Hu (University of Hawaii) et al. **Right: The most distant galaxy group (members are circled) lies in Virgo.** European Southern Observatory

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STAR CLUSTERS

Novel Clusters Stun Scientists

▶ For hundreds of years, astronomers have recognized two basic types of star clusters: ancient, massive globular clusters and young, less concentrated open clusters. It now appears that we may have to make room for a third member in the cluster pantheon.

The new objects appear much larger and fainter than typical globular clusters yet are vastly older than open clusters. Jean Brodie and Søren Larsen of the University of California, Santa Cruz, first detected the new objects — which they call "faint extended clusters" — in Hubble Space Telescope images of the lenticular galaxy NGC 1023 in Perseus.

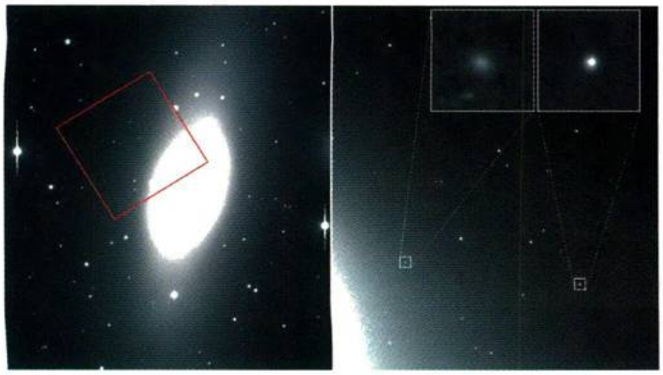
"It's no surprise these objects had never been seen before," says Brodie, "because they are very faint. In all the data archives from the Hubble Space Telescope, there are only four galaxies for which we have good enough observations to be able to detect them." The researchers discovered these cosmic misfits in only NGC 1023 and one other galaxy, the nearby lenticular NGC 3384 in Leo, ruling out their existence in the other two.

The new clusters glow much fainter than the bright, densely packed globulars, which typically contain hundreds of thousands of very old stars crammed into a sphere some 15 to 20 light-years in diameter. The Hubble observations reveal that the extended faint clusters measure from 50 to 100 light-years across. (Interestingly, the observations also show the constituent stars to be red, implying that they are ancient and may rival the age of the stars in globulars, which usually are the oldest in a galaxy.)

Another important difference: The new clusters seem to belong to the disk component of the galaxy while globulars belong exclusively to a galaxy's halo. "The association with the disk is significant because it means they probably formed in a very different way from globular clusters," says Larsen.

With only a relative handful of faint extended clusters located in just two galaxies, there's still a lot astronomers need to learn. "At this point, we don't know how common these clusters are or if they occur exclusively in lenticular galaxies," says Brodie. "And though we have some speculation as to how they may have formed, we have no explanation of why they are so large." — R. T.

The Keck Telescope captured this view of the nearby lenticular galaxy NGC 1023 (left). Hubble imaged the area outlined in red (right), capturing a newly discovered faint extended cluster (left inset) and a normal globular cluster (right inset). Søren Larsen (UCSC) and NASA



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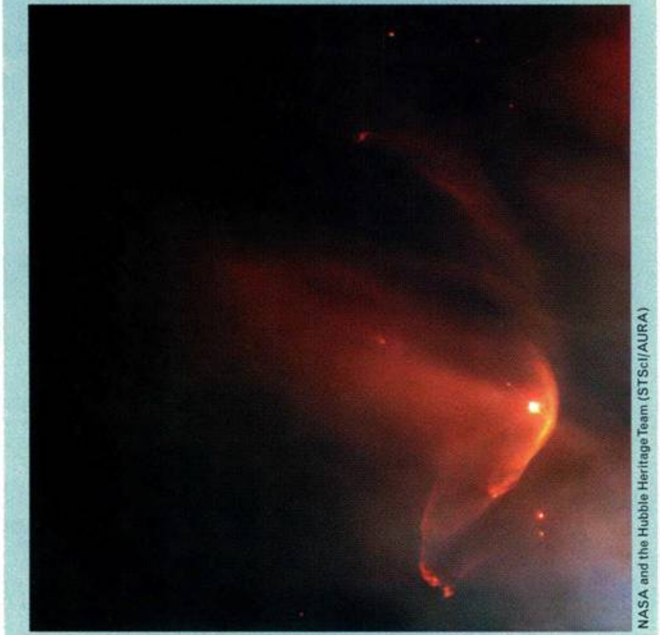

NASA and the Hubble Heritage Team (STScI/AURA)

LIKE A SHIP PLOWING ACROSS A CALM SEA, the extremely young star LL Orionis creates a bow shock in its surroundings. Located inside the Orion Nebula (M42), an intense star-forming region some 1,500 light-years from Earth, LL Orionis emits a vigorous stellar wind. This stream of charged particles moves rapidly away from the star, where it collides with slow-moving gas evaporating away from the center of the nebula (to the lower right of this Hubble image). The crescent-shaped bow shock forms where the two winds collide. The filamentary emission has a distinct boundary on the side facing away from LL Orionis but appears more diffuse on the side closer to the star, a characteristic common to many bow shocks. This structure is just one of many bow shocks discovered in the Orion Nebula. Astronomers hope that these observations will help them to better understand the complex process that leads to the birth of stars.

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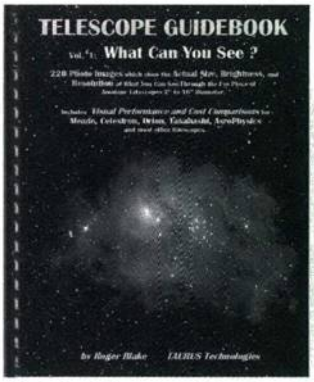
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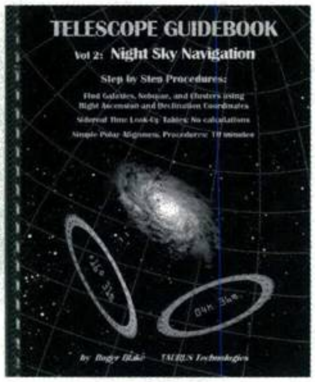
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well-nigh impossible — after all, humans have yet to invent a time machine, and the prospects don't look all that promising.

Fortunately, the universe has taken care of the problem. Because light travels at a finite speed (albeit a rapid one of 186,000 miles per second), we see objects as they were in the past. We see the sun as it was about 8 minutes ago, Sirius as it was 9 years ago, and the Andromeda Galaxy as it was 2.2 million years ago. The farther astronomers look into space, the farther back they see in time.

But to see how the universe evolved, you have to go way back. Viewing galaxies even a billion light-years away doesn't help a lot — it's a bit like trying to figure out how an 80-year-old woman has aged since birth by looking at a bunch of 75-year-olds. Very distant objects also tend to be very faint, requiring large telescopes and long exposures. And to get good statistics, lots of galaxies need to be observed. The task seems almost as hopeless as building a time machine.

Enter VIMOS. Short for the VIsible Multi-Object Spectrograph, VIMOS will be attached to the powerful 8.2-meter Very Large Telescope (VLT) at the European Southern Observatory in Chile. It has the capability of taking simultaneous spectra of a thousand different objects and, in one mode, up to 6,400 spectra during a single exposure.

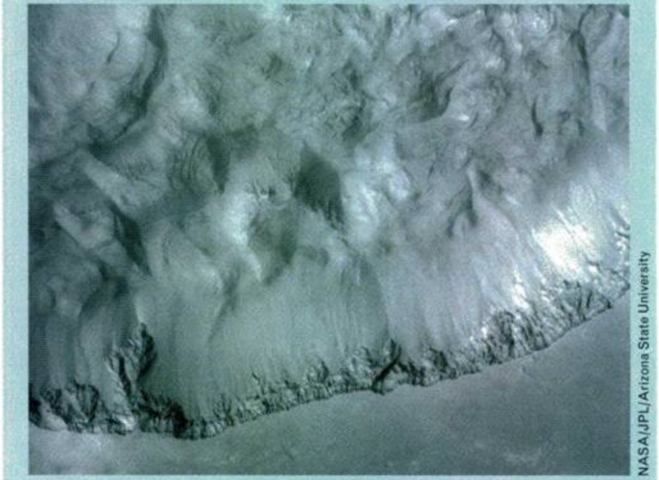
VIMOS achieved first light on February 26, taking images of nebulae, galaxies (like the colliding galaxies of the Antennae shown below), and galaxy clusters. It began taking spectra later that week. The instrument has a field of view half the size of the full moon.

Capturing spectra of many objects at the same time, or of multiple parts of the same object, requires letting light from only specific parts of the telescope's field of view into the spectrograph. Creating masks to accomplish this feat — which must be different for each object — falls to the Mask Manufacturing Unit. It uses a laser to cut slits in a mask that correspond to the areas where researchers desire a spectrum.

VIMOS will allow astronomers to map the distribution of galaxies, galaxy clusters, and quasars out to some 13 billion light-years, or 90 percent of the way back to the Big Bang. They will see how galaxies cluster in space, and how their distribution changes with time. These observations, in turn, will help constrain models of the universe's evolution, pointing astronomers closer to their holy grail. — R. T.

The Antennae (NGC 4038/39) were among the first targets for the new VIMOS instrument. ESO

MARS ODYSSEY



NASA/JPL/Arizona State University

IF HUGE VOLCANOES, DEEP CANYONS, and ice-covered plains whet your sightseeing appetite, Mars just may be the place for you. And now the World Wide Web can feed that hunger. Starting March 27, images of the Red Planet taken by the Thermal Emission Imaging System (THEMIS) on the Mars Odyssey spacecraft have been posted every weekday on the THEMIS website (http://themis.asu.edu/latest.html). Each image of the martian surface has a resolution of 60 feet (18 meters). Among the early releases was this view of a landslide in Ganges Chasma, a small part of the huge network of canyons known as Valles Marineris. This immense landslide started at the top of the scarp (visible near the bottom of the image), dropped down almost vertically, and then traveled some 40 miles (70 km) at speeds that likely exceeded 60 miles per hour.

VOYAGER 1 SPACECRAFT

Long-Distance Repair Call

▶ Voyager 1 has finally started to show its age. And no wonder: The spacecraft is a full quarter century into its originally planned four-year mission. Unfortunately, NASA can't launch a servicing mission to a spacecraft that's now more than twice as far away as Pluto. Yet with a little ingenuity — okay, a lot of ingenuity — the space

Voyager 1 captured this unique view of Saturn during its November 1980 flyby. NASA/JPL

agency found a way to nurse it back to health.

During the past two years, Voyager 1's attitude-control system had been showing signs of trouble. According to Tim Hogle, a flight-team engineer at the Jet Propulsion Laboratory, the problem was traced to an electronic component that takes analog signals from position-sensing devices and converts them to digital signals for the onboard computer. Luckily, the original design team had built backup systems into Voyager.

The attitude-control system's design, however, meant that switching to the suspect component's backup also required activating the backup sun sensor and star tracker, which provide the reference points for orienting the spacecraft. And the backups had not been tested since Voyager 1 was approaching Saturn in 1980.

"We had to plan this switch very carefully," says Hogle. The spacecraft lies at a distance of 7.8 billion miles (12.5 billion km), so one-way communications take nearly 12 hours. And the switch had the potential to confuse the computer about the spacecraft's orientation, which might have caused it to slew the antenna so it no longer pointed toward Earth.

The team decided to program a temporary changeover that would automatically revert to the original system after nine days — enough time to evaluate the backup and correct any problems. The plan worked, and the flight team finished calibrating the backup system on April 1.

"After sitting on the shelf for 25 years, it's like new equipment," says Voyager project manager Ed Massey. Voyager 1 and its twin, Voyager 2, are now set to continue their mission. The spacecraft are heading toward the heliopause — the boundary zone where the sun's influence gives way to interstellar space. Barring any further problems, the two should be able to keep exploring that frontier for another 20 years. — R. T.

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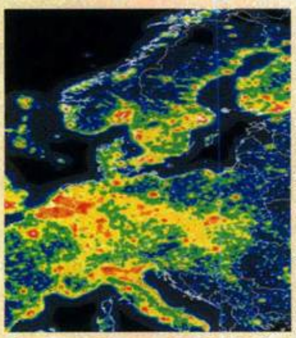
Wanted: NASA Research Subjects

Ever wanted to feel what it's like aboard the space shuttle during takeoff or landing? Or maybe you just like spinning around in circles? If this sounds like fun, then Malcolm Cohen wants to hear from you. Cohen, chief of NASA's Human Information Processing Branch, is looking for a few good men to participate in a study to determine how people tolerate prolonged exposure to increased gravity. Cohen seeks men between the ages of 18 and 35 who are 5 feet 8 inches tall or shorter. The study begins in July and will run for nine weeks. Those selected must be willing to ride on NASA's centrifuge for up to 22 hours nonstop at G forces up to twice normal. NASA warns that participants may experience motion sickness, blackouts, fainting, cardiac arrhythmias, disorientation, and dizziness. If you're still interested, contact Abigail Bautista by phone at (650) 604-5464 or via email at abautista@mail.arc.nasa.gov.

Putting a Czech on Light Pollution

The stars may soon shine a little brighter over Eastern Europe. The Czech Republic recently became the first country to enact national legislation that seeks to eliminate light pollution. Known as the "Protection of the Atmosphere Act," the bill addresses both light and other kinds of air pollution. The bill passed both houses of parliament and was signed into law by President Vaclav Havel on February 27. It officially takes effect on June 1. The law defines light pollution as "every form of illumination by artificial light which is dispersed outside the areas it is dedicated to, particularly if directed above the level of the horizon." Violators will be subject to fines ranging from 500 to 150,000 Czech crowns (roughly $15 to $4,400).



P. Cinzano (University of Padua), et al., and NASA

Europe's ablaze with light, but the Czechs may change that.

Pulsar Theories May Be Wrong

For the second time in the past two years, astronomers have found a pulsar that doesn't conform to theory. In 2000, Victoria Kaspi of McGill University in Montreal, Canada, and her colleagues discovered a pulsar that proved to be far younger than thought. Now a team of researchers led by Joshua Migliazzo of the Massachusetts Institute of Technology has shown that the pulsar B1951+32 in Cygnus appears only half as old as theory says it should be. Using the Very Large Array radio telescope, the team found the pulsar's speed and position relative to the supernova remnant CTB 80 — born in the explosion that created B1951+32 — and calculated that it formed 64,000 years ago. Yet the pulsar's rapid spin is slowing at a pace that suggests it was born 107,000 years ago.

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Moving Right

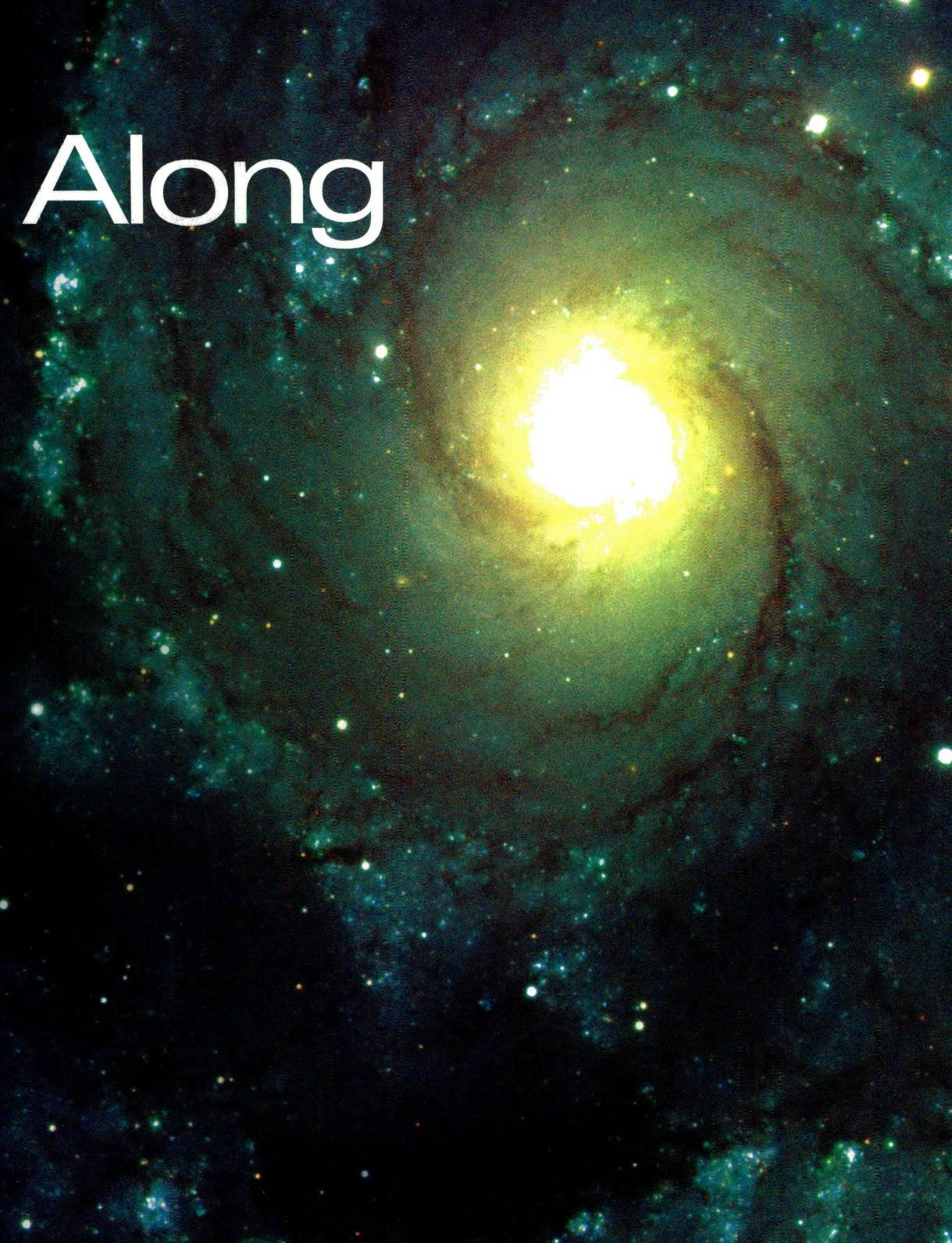
The accelerating universe holds secrets to dark energy, the Big Bang, and the ultimate beauty of nature.

by Mario Livio

On a cold March day in 1998, the universe was knocked on its head. That day, Adam Riess, currently at the Space Telescope Science Institute, submitted a paper on behalf of the High-z Supernova Team, which concluded that the universe's expansion is accelerating. Instead of slowing down, as would be expected from the fact that the cosmic expansion occurs against the gravitational pull of all matter within the universe, the universe is speeding up, as if propelled by some repulsive force associated with a mysterious "dark energy." Riess's team, led by Brian Schmidt of Mount Stromlo Observatory, was not alone in this discovery. A second team, led by Saul Perlmutter of Lawrence Berkeley National Laboratory, also found evidence that the expansion of the universe is accelerating.

Image of NGC 2997 courtesy ESO

Along



The idea that a repulsive force acts on the universe is startling, but hardly new. In 1917, when Albert Einstein first tried to apply his Theory of General Relativity to the entire cosmos, he had to introduce this kind of force to hold the universe static. At the time, Einstein wasn't aware of the fact that the universe is expanding, so he introduced a repulsive force at large distances, the cosmological constant, to which he assigned an arbitrary number. This "fudge factor" was brought into relativity to support the universe against its own weight. Things changed when Edwin Hubble arrived on the scene. Some time after Hubble discovered the expansion of the universe, in 1931, Einstein removed what appeared to be an unnecessary complication from his equations, calling it his "biggest blunder."

Taking a Dusty Test

So exactly how do astronomers know the universal expansion is accelerating? The two teams looked at Type Ia supernovae at very large distances (high-redshift). The tremendous explosions from Type Ia supernovae are catastrophic thermonuclear disruptions of white dwarf stars that occur when the stars reach their maximum possible mass — the so-called Chandrasekhar limit of 1.4 solar masses. Two characteristics of these explosions make Type Ia supernovae excellent "standard candles" — gauges of distance. First, the brightnesses of the explosions are nearly constant. Second, the small differences from constancy are also well known — the brighter the supernova, the slower it declines in brightness — so that astronomers can use them to determine cosmic distances. The 1998 observations showed that very distant supernovae, those with redshifts of 0.5 and higher, appeared some 0.3 magnitude dimmer than expected at their distances, and therefore the expansion rate of the universe had to be speeding up (for the supernovae to reach larger distances).

Observations of distant supernovae and of the cosmic microwave background strongly suggest we are living in an accelerating universe.

The first skeptics wondered whether the observations from 1998 might be tainted. For example, was it possible that the supernovae appeared so faint because of obscuring dust lying between us and them? After all, as the saying goes, extraordinary claims require extraordinary proof. In 2001, however, Riess and his colleagues made a big step toward showing that alternative explanations like dust absorption do not explain the faintness. Using Hubble Space Telescope observations of the Hubble Deep Field, the deepest exposure ever made in the visible light/ultraviolet wavelengths, the group showed that Supernova 1997ff, which lies in the field, is the most distant Type Ia supernova known. Its amazingly high redshift of 1.7, which corresponds to a whopping 10.2 billion years ago, offers astronomers a unique opportunity to test the idea that dust is obscuring the observations.

The idea is simple. Even in a universe that's currently accelerating, if you look into the distant past, you're bound to find an era when the universe was decelerating. When the universe was very small, gravity still dominated the dynamics of the cosmos, and the expansion was slowed down by gravity's pull. Only in the last few billion years did the matter density of the universe dip below the density associated with dark energy, and the expansion of the universe began to speed up. Because of this, observations of supernovae with redshifts greater than 1.5 can distinguish between obscuration by dust and the real thing — acceleration. If supernovae are dimmed by dust, then more distant ones should appear fainter and fainter, as their light needs to pass through ever-increasing amounts of dust.

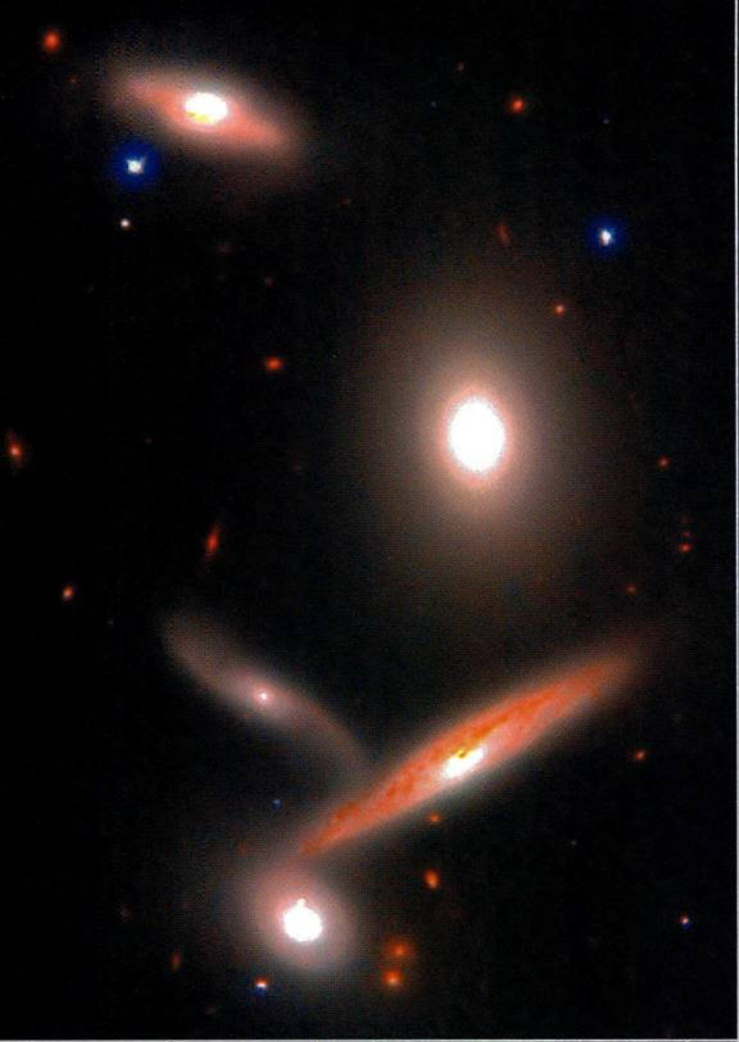
The Accelerating Universe

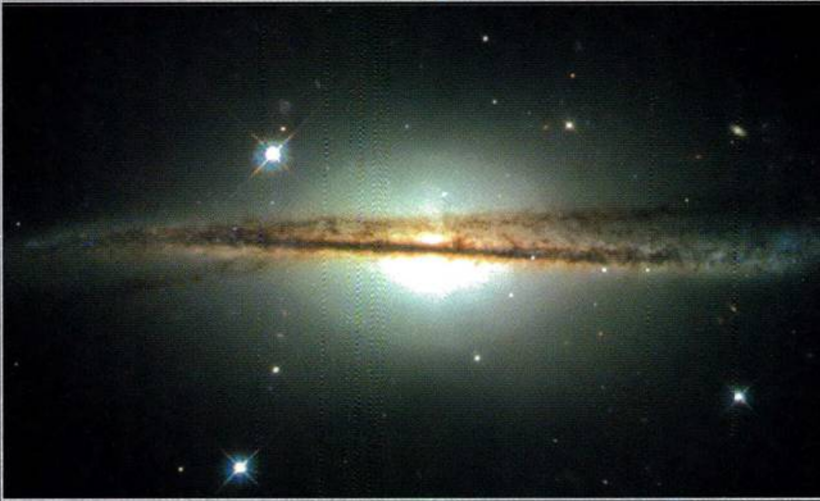
If, on the other hand, we live in an accelerating universe, then supernovae at very high redshifts (seen when the universe was still decelerating) should look brighter than expected for their distance. Indeed, the observations of Supernova 1997ff show it to be brighter than anticipated, corresponding to the predictions of cosmic acceleration rather than to dust obscuration. Supernova observations also suggest that we live in a universe in which matter in all forms, including dark matter, creates only about 30 to 35 percent of the density that makes the universe geometrically flat. The other 65 percent of the density comes from the as-yet mysterious dark energy. Astronomers use the letter ω to denote the cosmic density in units of the critical density (that would separate eternal expansion from eventual contraction if there were no dark energy). A value of ω that is equal to 1.0 corresponds to a geometrically flat universe. If ω is greater than 1.0, then the universe would be closed, corresponding to a geometry like that of a sphere. If ω is smaller than 1.0, then the universe is open with a geometry like that of a saddle. A flat universe with a dark energy contribution of 65 percent is expected to expand forever, at an ever-increasing rate.

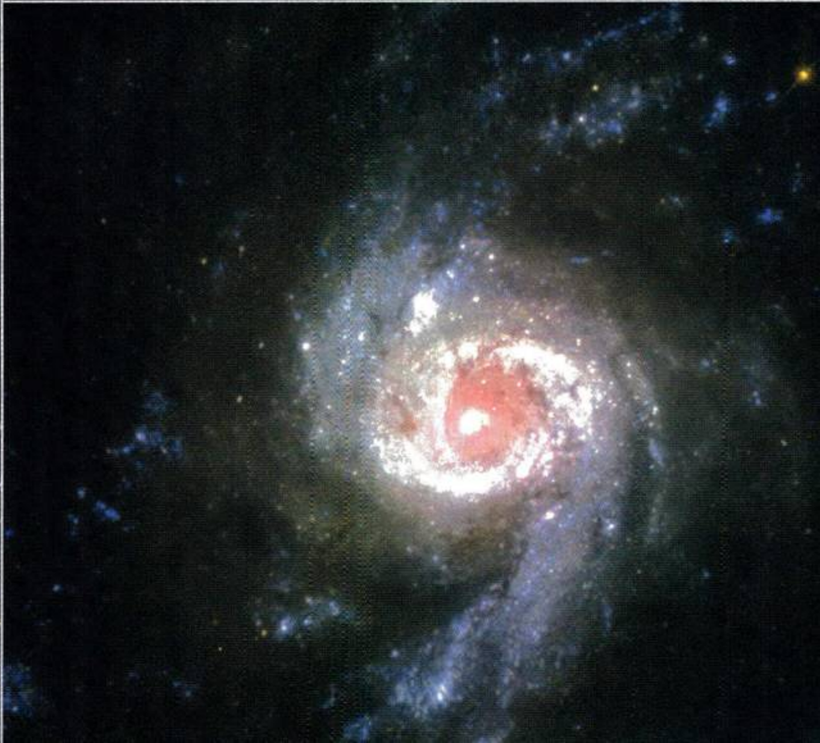
Another bit of evidence strongly suggests that the universe is speeding up. Astronomers have for years observed the Cosmic Microwave Background (CMB) radiation. Measurements of the anisotropy (unevenness) of the CMB radiation across the sky show that the difference in temperatures between two points on the sky is greatest when the two spots are about 1° apart. Why is this important? It's a reflection of the geometry of the universe. The CMB radiation is coming from the "surface" on which radiation particles, photons, last interacted with matter in the early universe, before the universe became transparent. As baryons and leptons — ions and electrons — fell into the potential wells generated by dark matter, photons pushed against them, which generated acoustic oscillations. The waves generated from this process undulated the surface on which the CMB radiation was emitted, creating fluctuations in the temperature of the universe.

In the same way that sounds produced on the head of a drum depend on the drum's size and geometry, the longest wavelength that had time to oscillate in the CMB depended on the geometry of the universe — on the value of ω. In particular, a peak in the temperature differences for points on the sky 1° apart corresponds to a flat universe, an ω of 1.0. If ω is smaller than 1.0, the differences in temperatures are largest between points separated by less than 1°. It's similar to the

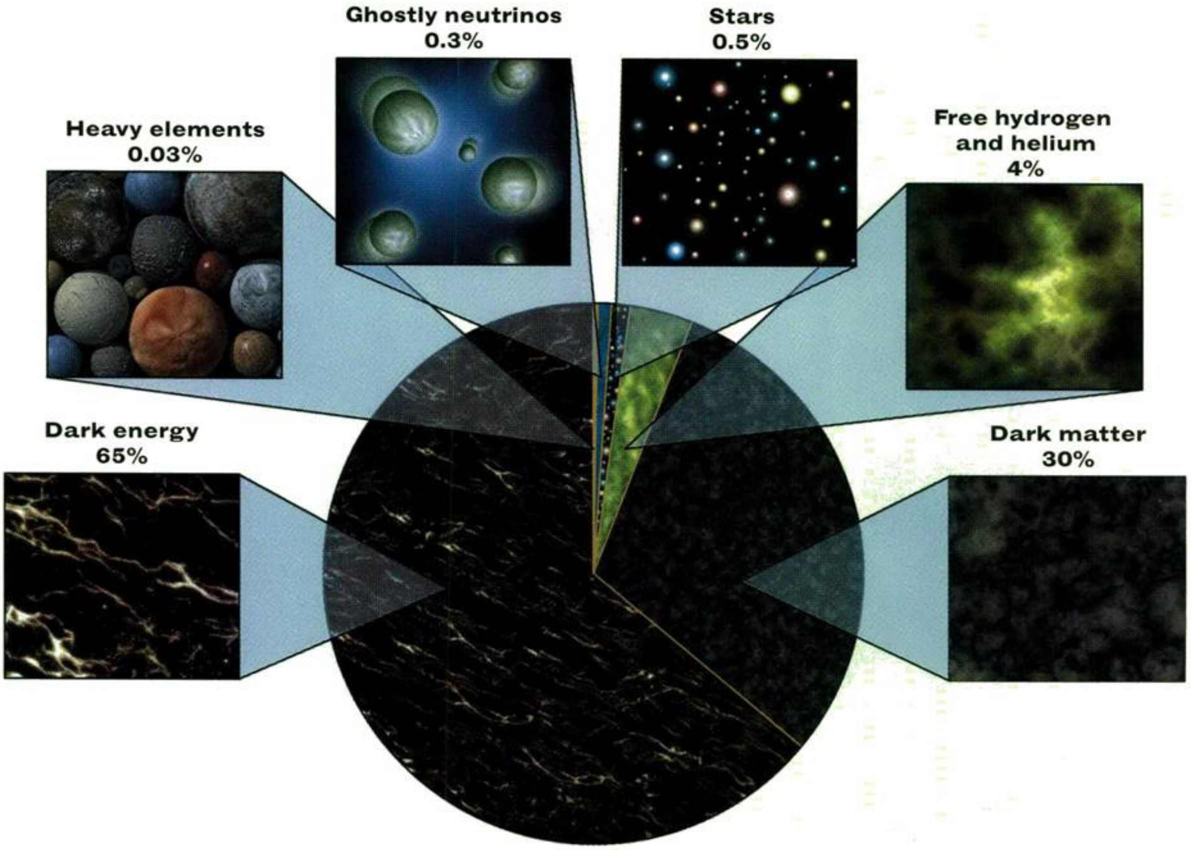
Clockwise, from top left, a gallery of galaxies being pushed outward by the accelerating universe: Galaxy group Hickson 40, a flurry of objects in the southern constellation Hydra; spiral M63 in Canes Venatici, which has tightly-wrapped arms; edge-on spiral ESO 510–G13; barred spiral NGC 3310 in Ursa Major; and southern galaxy ESO 269–57, which displays a strong ringlike structure. NASA/STScI and ESO







Types of Matter and Energy in the Cosmos



Is There Beauty in Nature?

What do physicists mean when they label a certain theory as beautiful? The definition of "beauty" in Webster's *Dictionary* reads: "The quality which makes an object seem pleasing or satisfying in a certain way." While this may be a pretty good definition for a beautiful work of art, physicists don't quite mean the same thing.

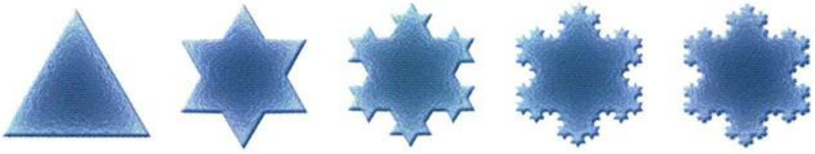
The two main parts of beautiful theories are symmetry and simplicity. By "symmetry" I don't mean the symmetry of shapes or objects, like the left-right symmetry of the human face, but the symmetry of the laws of physics themselves, such as the fact that they don't change from place to place in the universe. This is what makes astronomy and astrophysics possible. We can use the same laws of electromagnetism that were deduced from laboratory experiments on Earth to study a galaxy that is a billion light-years away. The laws of physics are also symmetrical under rotations; physics has no preferred direction in space.

Separating the symmetry of shapes and that of laws is best exemplified by looking at planetary orbits. From ancient Greece to Galileo Galilei's time, astronomers had assumed that planetary orbits must be circular because of a circle's symmetry. Consequently, when Kepler discovered that orbits were elliptical, even Galileo refused to accept the finding.

Not having Newton's Law of Gravitation at his disposal, Galileo didn't recognize that symmetry under rotation is a property of the law and not of the shape of the orbit. In other words, the orbits can be, and indeed are, ellipses, but the symmetry of the Law of Gravitation under rotation implies that the ellipses are allowed to have any orientation in space.

By simplicity I mean reductionism. The goal of physics has always been to explain the wealth of phenomena we observe in nature by a relatively small number of fundamental laws. Consider star birth in gas clouds, the deaths of stars like the sun, and the collision of two galaxies. All these processes involve four basic interactions: gravity, electromagnetism, and the two nuclear forces.

"Geometry, which before the origin of things was coeternal with the divine mind," Kepler wrote, "supplied God with patterns for the creation of the world." Accordingly, he wrote an entire treatise on "The Six-Cornered Snowflake," investigating why snowflakes have a six-fold symmetry. This curiosity and inquisitiveness is the backbone of science. — *M. L.*



experiment you can create by holding a penny close to your eye, where it covers a wider angle of your field of view than if you hold it farther away from your eye. A number of experiments analyzing the CMB suggest that the density of matter in all forms is about 35 percent of the critical, and that dark energy represents 65 percent.

Astronomers know that the dark energy component of the energy density did not interfere with the formation of the structures we observe today in the universe (it was therefore less important in the past). Based on this, one can show that the dark energy has a negative pressure. However, in General Relativity, gravity acts proportionally to the sum of the matter density and three times the pressure. For a sufficiently negative pressure, therefore, gravity becomes a repulsive force, leading to the acceleration of the universe's expansion.

Beauty in Distress?

The observations of distant supernovae and of the CMB strongly suggest that we live in an accelerating universe, in which the energy density is dominated by some mysterious form of dark energy. There's a problem attached to this finding, however. The model of the universe that emerges from these findings is preposterously complex. Physicists normally assume that fundamental theories of the universe must be "beautiful" — that is, successful theories are based on symmetry and simplicity (see the opposite page). A physicist's aesthetic sensibility is really an important research tool that helps in narrowing down ideas to a correct hypothesis. The best example of this is Einstein's General Relativity, which in Einstein's words was "beautiful beyond comparison."

> Are we facing a breakdown of some of our most cherished theories of the universe?

In General Relativity, the underlying symmetry comes from the idea that all frames of reference are equal. In other words, whether we live on a rocket moving at a constant speed, on a clump accelerating from an exploding supernova, or on the surface of a rapidly spinning star, the laws of nature look the same.

But does General Relativity fit into the theme of symmetry and simplicity? Isn't it notoriously complicated? After all, in 1915 Einstein himself said that "only one colleague [mathematician David Hilbert] has really been able to understand it." Indeed, the equations describing General Relativity and their solutions are more complex than Newton's Theory of Gravitation, but the central idea is actually much simpler. Instead of being a mysterious force that acts across space, gravity merely reflects the geometry of space-time. In the same way that a heavy bowling ball resting on a tight rubber mat would cause it to sag, every mass warps space-time in its vicinity. The planets move along curved orbits because they follow the most natural paths in the curved space-time produced by the sun. Similarly, an airplane flying from the United States to Europe follows a great circle along Earth's surface.

So where's the symmetry and simplicity in the new model of the cosmos? The values of the different energy densities appear to be anything but simple. In fact, the value for the dark energy, 65 percent, is bizarre. The most "natural" value for the energy density should have come from the so-called Planck Era, when the universe was 10^{-43} seconds old. But that value is some 123 orders of magnitude larger than the value that astronomers observe — a huge discrepancy even by astronomical standards. When adjustments are made for the concept of supersymmetry, for example, the energy density value is still 55 orders of magnitude too large. Attempts to reconcile this difference by making the dark energy evolve over time still require some fine-tuning. It's difficult to accept the notion that somehow the effect of the dark energy changed in the recent past; theories of the universe are usually Copernican—they rely on humans as ordinary observers, not graced with some special time or place to make things feasible.

Does this mean that we are facing a breakdown of some of our most cherished theories of the universe? Has the centuries-old assumption of a simple, symmetric, Copernican theory of the universe reached its limits?

I don't think so. We are probably in the same situation that the famous physicist Isidor Rabi found himself when he heard about the discovery of the muon. "Who ordered that?" he indignantly asked. Assuming all the findings on the values of ω will be confirmed, I believe that in time we'll find that the current confusion relates to what is really fundamental and what isn't. Galileo was upset by elliptical orbits because he didn't realize the shape and symmetry of the orbits was not fundamental — the symmetry of gravity was. Kepler wrote an entire, outrageously wrong treatise trying to explain the number of planets and sizes of their orbits because he thought these things were fundamental. Before the standard model of particle physics emerged, accelerators were finding scores of particles, most of which are now known to be simply excited states of collections of two or three quarks.

It's quite possible that astronomers will eventually realize that the only truly fundamental value is ω, and that $\omega = 1.0$ and the universe is flat. This is a direct result of inflation, which has all the hallmarks of a simple, symmetric, and Copernican theory. The mere existence of a cosmological constant is not inconsistent with the symmetry principle of General Relativity — that the laws of nature should be the same in all frames of reference in space and time.

But other possibilities exist. Alternative theories of gravity have been proposed. They rely on extra dimensions (more than our three for space and one for time) to suggest that what we see as dark matter halos may in fact reflect the gravitational influence of matter in other universes. The idea is that while all interactions are confined to our universe, gravity may be free to travel in a fifth dimension, and thus from one universe to another. These ideas are highly speculative. But perhaps they could be tested by measuring the strength of gravity on very small (submillimeter) scales.

No fewer than five experiments are in the works to test this idea. Experiments at the Large Hadron Collector in Geneva, Switzerland, in the next decade may also be able to test these ideas by discovering events of missing energy—gravitons escaping into a fifth dimension. If these alternative ideas about gravity are confirmed, it would mean that the beauty of the universe may not be in jeopardy at all — our understanding of it simply needs to play catch-up.

Mario Livio is head of the Science Division at the Space Telescope Science Institute in Baltimore. He is the author of The Accelerating Universe *(Wiley, 2000) and* The Golden Ratio *(Doubleday/Broadway, 2002).*

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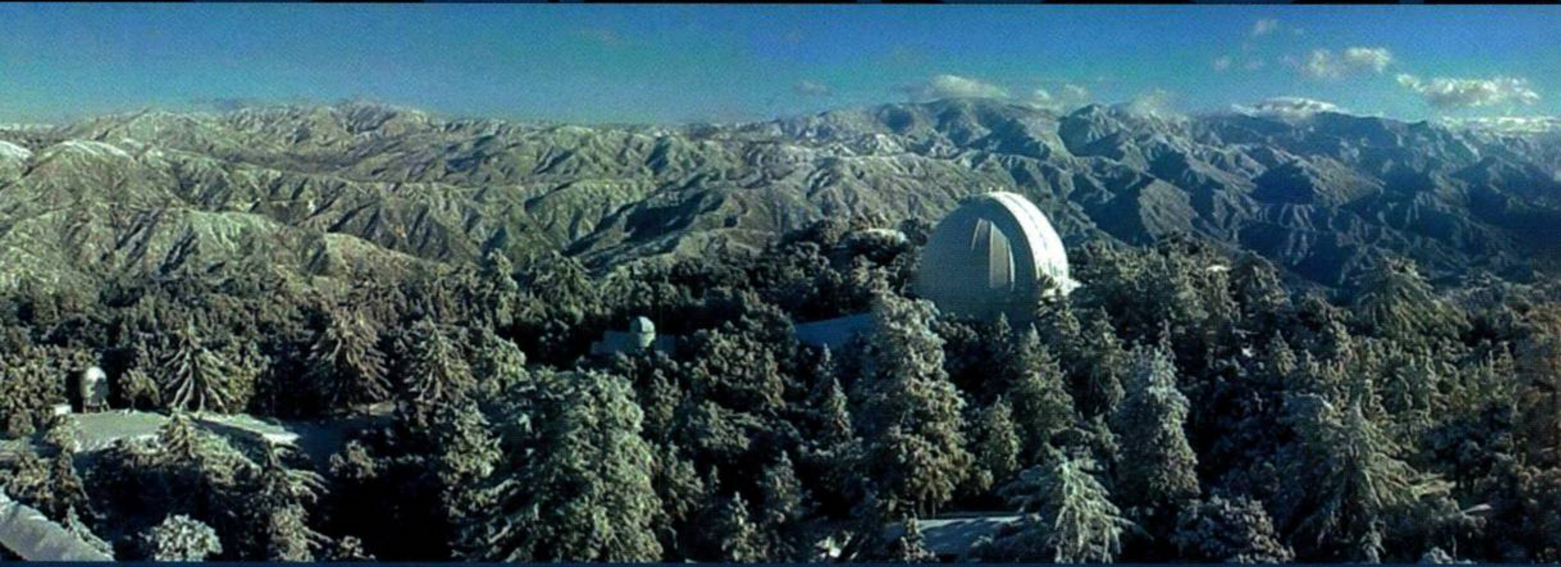


TELESCOPES IN EDUCATION MARKS A DECADE OF GIVING

A picture may be worth a thousand words, but sometimes it's better to get your hands dirty. When it comes to teaching astronomy to schoolkids, award-winning education innovator Gil Clark thinks "dirty hands" means getting real observing experience on a real — meaning large — telescope. It's hard to argue with the idea until you realize there may be a gap of hundreds or even thousands of miles between the kids' hands and the telescope experience.

Gil Clark is intent on bridging that gap. For the last 10 years, Clark, the director of Telescopes in Education (TIE), has given hundreds of U.S. schoolchildren remote access to telescopes. Since the program's inception in 1992, students from Los Angeles to Manhattan

OOMS

Look to the Stars

SCHOOLKIDS ACCESS TO BIG SCOPES. BY ADAM FRANK

Mount Wilson panorama by Colleen Gino and Steven Padilla

have used TIE's instruments via modems and the Internet to generate their own astronomical images and even shape their own research programs. Images are not, however, the only thing kids in the TIE program generate. The excitement of doing science for themselves, by themselves, has changed students' views of the scientific process, transformed schools' education programs, and even propelled a number of kids into science careers.

Now, after 10 years of success, the TIE program is poised for a dramatic expansion that will open up the southern night for U.S. students. The southern sky effort will extend students' virtual presence to observatories in the remote mountains of Chile and the dry deserts of Australia. For Clark and the TIE program, the expansion requires combining the

Left to right: A million stars gleam in the globular cluster M13; TIE director Gil Clark stands in the dome of the Mount Wilson 24-inch scope, which took all the object photos; the Trapezium lies at the heart of the Orion Nebula. April Labrecque; Chris Wahlberg; Colleen Gino

high technology of digital imaging and network communications with the distinctly lower technology of good international diplomacy. As the new telescopes come online, Clark and his team are eager to give students their first taste of the southern sky's wonders. But Clark's path to the Southern Hemisphere has not been easy. He has built the TIE program from the ground up with little more than perseverance and the seemingly boundless goodwill of volunteers.

Gil Clark is a man of surprising qualities. One of the first surprises waiting for a visitor is learning that this soft-spoken visionary who shaped the Telescopes in Education project is not an astronomer. Clark's experience with TIE began in 1991 when he was an engineer and manager at NASA's Jet Propulsion Laboratory. "I decided we needed to do something for schoolkids in astronomy that would really get them excited," says Clark. After some outreach experiences at JPL, Clark became convinced that simply looking at books would never make science special for students.

"Being at JPL, one of the first things that occurred to me was trying to give kids an experience of seeing what a scientific-grade telescope sees," Clark explains. "That is not an opportunity they usually get." Clark began working to build a large CCD-enabled telescope that students could call in to use at predetermined times. "The idea was the students would control just the camera," says Clark. "The pictures would then be sent back to them via modem." Before Clark was forced to embark down the path of building his own telescope, fate intervened in the form of two famous astronomers from Mount Wilson Observatory. "Robert Jastrow and Sallie Baliunas had heard what I wanted to do," says Clark. "They came over to JPL and had lunch with me. After we talked awhile they invited me to fully automate an existing telescope at Mount Wilson."

The telescope they offered Clark was, in his words, "a grand old instrument." It was a good thing Clark had such fond feelings for the apparatus because it was also in a state of complete disrepair. "They had this beautiful 24-inch," Clark recalls, "that was built in the early moon-exploration days. Some researchers at Caltech actually constructed it to show that the lunar surface was something you could land on and not a mile-deep layer of dust." Despite the telescope's semi-glorious past, when Clark found it, the 24-inch needed to be fully reassembled and refurbished. "It had been beaten up pretty badly," says Clark, "but Caltech was willing to take a guy that had once worked on it out of retirement and make sure all the parts were there."

Fit to Be Tied

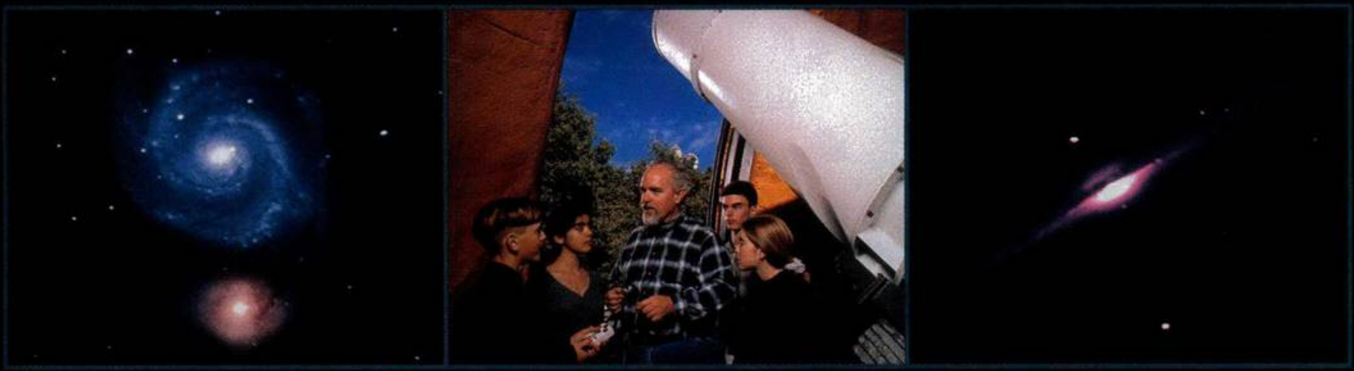
Caltech and Mount Wilson's generosity were to be Clark's first experience with the goodwill his project inspires in people. After the 24-inch telescope was rebuilt, an automation expert from Colorado, Tom Melsheimer, agreed to donate both his effort and expenses to make the telescope remotely accessible. "Tom and his wife flew out here three or four times to help us. They paid for it out of their own pocket," explains Clark. "They just thought this was the most tremendous thing that could be done for education."

Once the telescope was ready, TIE began operations with two schools located at opposite ends of the country: the Thomas Jefferson School in Alexandria, Virginia, and the Apple Valley Science and Technology Center in Apple Valley, California. All through the spring and summer of 1993, students from the two schools tested the Mount Wilson telescope and its remote observing capabilities. "We set things up so that there was always an operator in the dome even though the students were controlling the telescope," explains Clark. "Students could phone in as they were doing their observations and actually hear the gears engaging." By the fall of 1993, TIE was officially up and running. "We opened the program for all comers," says Clark with a smile.

He now has reason to be satisfied. In the nine years since they began accepting applications, more than 300 schools have signed up for the program. "We got saturated pretty quickly," he says. "Now there is a two- or three-month waiting period on the scheduling."

Clark and his team have worked hard to streamline the procedure for new schools to join the TIE program. An interested teacher first has to send Clark a letter with the school's letterhead on it. "We need to make sure that this resource goes to the people we intended it for," says Clark. The only investment a school must make is the purchase of telescope control software designed especially for the TIE program by Software Bisque. (The price is about $200 and helps the company recoup its costs.)

TIE then schedules the class for a daytime test to make sure the teachers and students have become familiar with the software. Once the class is daytime certified they are ready to take on the night. Just like professional astronomers, however, actually getting on the telescope can be a problem. "The demand is so high," says Clark, "that we can't schedule a school more than once a month unless



Left to right: The spiral galaxy M51 with Supernova 1994I (located just off the upper right corner of the nucleus); Gil Clark talks with students at the 24-inch scope; a dark lane of dust bisects the edge-on spiral galaxy NGC 4565. TIE program; Chris Wahlberg; TIE program

the students are doing some kind of ongoing research program."

When Clark speaks of student research, he does not mean simple book-report kind of stuff. "Students may just want to take pretty pictures at first, but that doesn't last," Clark explains. "The kids start asking questions about what they can do that is unique and unusual. That means research. We don't force it on them but we give their teachers latitude. As students progress, they gravitate toward the research-type things."

A Stellar Discovery

The potential for independent work has led some students to push their questioning right up to the professional level. "We had a high school student named Heath Gibson in the Pasadena area who decided he wanted to do something unique in competing for the Intel scholarship," says Clark. "He looked at variable stars, doing all the difficult hours of research and time on the telescope by himself." Within six months the budding astronomer had discovered a new variable star. Gibson's data convincingly demonstrated that this variable was actually an eclipsing binary, two stars whose mutual orbits line up so well with Earth's line of sight that each star periodically blots out the other's light.

Even if the student projects don't involve discoveries, they can still get pretty creative. "We had a grade school that wanted to do a family tree of the universe," says Clark. "They started filling a wall with images they had made of star clusters. They did globular clusters first, then open clusters. That gave them a sense of the inside of the Milky Way. After that they moved up in scale and started filling a wall with galaxy images. I really thought that was a great idea."

Impressive as it seems, a catalog of TIE projects can only tell a small piece of the program's story. For some classes, the addition of TIE has changed the entire school's science culture. "My students went crazy for it," says Jerry Musillo of the Trinity School, one of New York's more prestigious private educational institutions. Musillo was the technology director for the school, which, before the TIE program, had their best computer in the food services room.

"We had no astronomy curriculum at all and very few computers," Musillo explains. "Then I found Telescopes in Education and contacted Gil Clark. Before you knew it the students were getting proficient on the software. We were having regular observing sessions, and for us on the East Coast that means one or two o'clock in the morning." The student's drive and enthusiasm soon spread across the school. "Everybody was so enamored of this program that soon we had an astronomy club," adds Musillo. "I was able to put astronomy into the curriculum as a regular class, and then we had so many computers I couldn't count them."

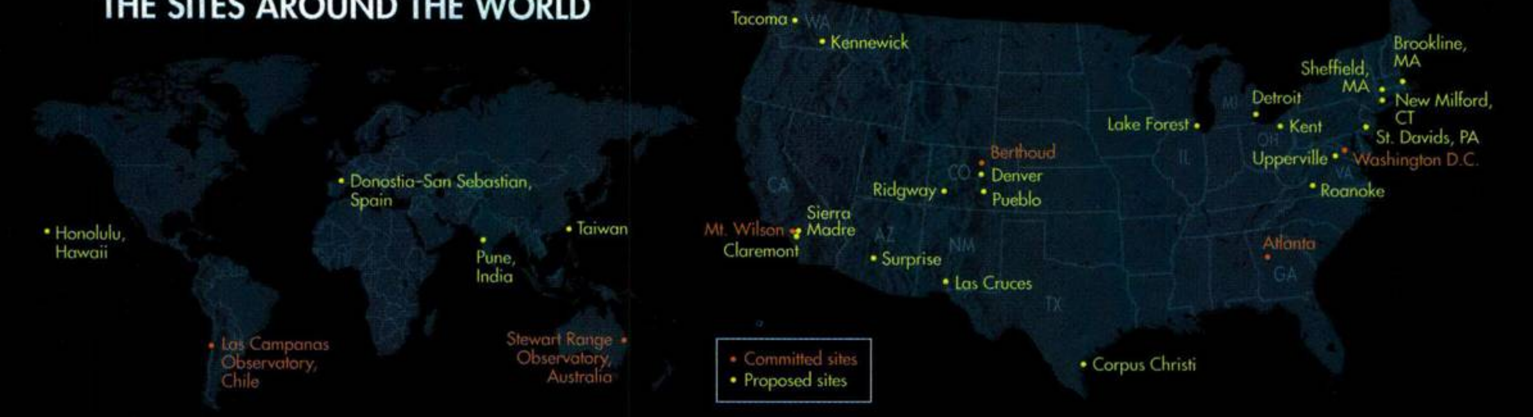
Clark's program was a success and, after just a few years, TIE's impact led to national recognition. In 1996 Gil Clark and TIE were awarded the prestigious Rolex Award for innovation. Not being one to rest on his laurels, Clark immediately put the funds from the award to work expanding the program. New telescopes were desperately needed to handle the overflow of students wanting to use the program's resources. The first question Clark faced was where to put new instruments. Time zones can play a detrimental role for students by forcing them to use the Mount Wilson telescope in the small hours of the night.

One of Clark's primary goals for the Rolex money was to locate a telescope that students could use during classroom hours. "I used a big chunk of the Rolex award going to Australia and Russia to see if we could get automated telescopes in those countries," says Clark. "But when they heard the name NASA they would ask 'How much are you going to pay us for this?' It did not work out very well."

Eventually an administrator at NASA Headquarters pointed Clark to Chile. Although it could not alleviate the time zone dilemma like Australia could, it still opened the potential for giving students a view of the sky they had never seen. "Chile was really interesting to us," says Clark, "because the Carnegie Foundation [which runs Mount Wilson] already has an observatory down there." Initial probes showed the Carnegie Observatory was favorable to the idea. Clark and Mark Leon, the manager of NASA's Learning Technology project, which helps fund TIE, then traveled to Chile to inspect facilities and communications. They quickly reached an "in principle" agreement to go ahead with the project.

Leon saw much in the Chilean site to recommend it. "The location alone gives you a unique perspective," he says. The site's position on Earth allows a portion of the sky visible there to overlap with what can be seen from Mount Wilson. "Students will see some of the same constellations from both sites," says Leon, "but down there they'll have a whole new domain of sky too." The collaboration Clark and Leon established involves the TIE program with both the Carnegie Observatory and the Chilean government. TIE will help develop an outreach effort to the local Chilean schools. The Chilean government will, in turn,

THE SITES AROUND THE WORLD



provide the facilities and staff to maintain the telescopes.

The plans for the southern TIE telescopes are ambitious. The first instrument on the site in Chile will be a 14-inch scope but other telescopes will soon join that pioneer. Clark and Leon are also developing a communications infrastructure that will support the control of the telescopes and allow video feeds in and around the instruments. “We'll have cameras down there positioned so that the kids can see the telescope,” Leon says. “We will also have cameras outside letting them see what the landscape looks like.”

Clark sees a strong justification for the enhanced tele-presence. “We're setting it up so the camera will pan around the area. You will be able to see the building, the background, and the other observatories in the area. That should provide a really solid connection for the students.” A really solid Internet connection is needed to beam all that information back from the remote Chilean mountains, however, and that presented Clark and Leon with a problem.

Providing a continuous real-time communications link that allows remote observing from such a remote location poses special challenges for the TIE program. “The Chilean network is so congested that it's beyond usability for our requirements,” says Leon. Another Internet solution had to be found. To establish a high-speed link between the telescopes and the student operators in the United States, Leon and Clark first considered using an exotic technology involving signals bouncing off the troposphere. “The FCC sold away the frequency bandwidth that we would have been using,” Leon explains, “so that was no longer available to us.”

The pockmarked surface of Earth's moon posed for the 24-inch TIE scope on Mount Wilson.

Colleen Gino and Scott Teare

Tying the World Together

The solution Leon devised involved implementing a sophisticated satellite communications link that will ensure remote access to the mountain. With the Internet link in place, the project is currently in its construction phase. First “virtual” light occurred in late 2001 and students should have access to the telescope by the end of this year.

Along with the Chile project, TIE has managed to expand in other directions. A second 14-inch instrument is now available along with the 24-inch telescope on Mount Wilson. Australia was finally brought into the fold with a 14-inch telescope located near Brisbane. Other instruments, which collaborate with the TIE program, include an 18-inch telescope on loan to a non-profit organization at the Little Thompson Observatory in Colorado and a 30-inch telescope based at the Fernbank Observatory in Georgia. The telescopes not only increase the pool of resources for TIE's students, they also make Clark an international player in new education and Internet initiatives.

Last year the TIE program was asked to act as the focal point for a demonstration of high data transfer technologies at the White House. Using a satellite link, students in Japan, California, and Virginia cooperated in jointly controlling one of TIE's 14-inch telescopes. Students were asked to collect specific images of globular clusters one evening and then image galaxies on the next scheduled run.

The most innovative part of the demonstration required all the students to be connected to the telescope at the same time. They could see what the others were doing in real time and a voice communications link allowed them to coordinate their observing run. When the images were collected, Patrick Shopbell (then at the University of Maryland) posted Hubble images of the same parts of the sky and then gave a lecture on the objects. Later the U.S. and Japanese students asked Shopbell questions and discussed what they had learned together.

From international goodwill efforts to just getting a seven-year-old psyched about supernovae, TIE has proven to be an unqualified success. For all its achievements, Clark is quick to point out that the vast majority of the program's effectiveness comes from the efforts of volunteers. After 10 years of working on the program, Clark is still surprised by the generosity of spirit TIE evokes in people. Always short on funds, Clark and TIE could not have survived without the dedication and perseverance of people whose only payback is the chance to let another kid see a live globular cluster.

“What is so amazing,” says Clark, “is that people give of their time so freely to help the program. We have everyone from tattoo artists to professional astronomers helping out. That is the only reason the program has been as strong as it is.” In the end, it seems, all the high technology that TIE brings to bear is only the gloss on the deeper sense of wonder and place that the night sky has always inspired.

University of Rochester astrophysicist Adam Frank is a member of Astronomy's *Editorial Advisory Board. His previous article was* “Lurking in the Shadows,” *in the January 2002 issue.*

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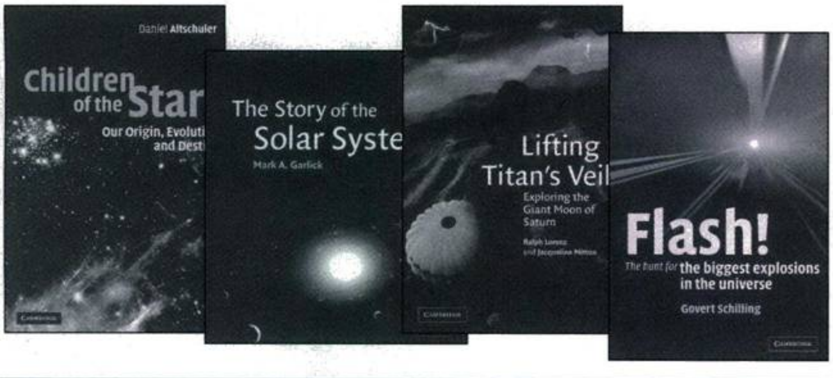
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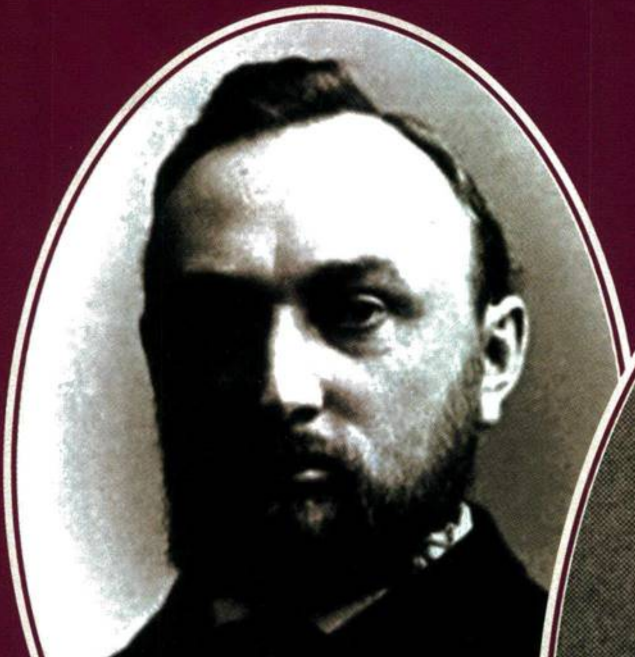


How a maid and her master changed the face and gender of astronomy forever.

As far as astronomical data-gathering goes, the story in 1880 was much the same as it is today: Too much archived raw data, too little time.

Observers were in a feeding frenzy to employ their brand-new photographic and spectroscopic techniques. Night after night, astronomers would photograph objects and simply box up the glass photographic negatives for later analysis. Observatory storerooms began to fill up with box upon box of carefully labeled astronomical data.

In America, the impetus behind the gathering backlog of astronomical data was largely the legacy of one man: a wealthy physician and amateur astronomer named Henry Draper. Draper was practically the poster child for the new astronomical techniques of photography and spectroscopy. In 1872, he was the first to photograph a stellar spectrum, introducing the world to an incredibly powerful tool for probing the physical properties of stars.

Like any good, obsessive amateur, Draper's ultimate goal was to photograph stellar spectra across the entire sky — northern and southern hemispheres — for he was rightly convinced that in spectra lay the answers to fundamental questions about the universe.

Unfortunately, Draper would never achieve this ultimate goal. He died suddenly of double pleurisy after returning from a Colorado hunting trip in 1882. But his shocked and grieving widow, Anna Palmer Draper, was determined that her husband's dream be realized.

Meanwhile at the Harvard College Observatory (HCO) in Cambridge, Massachusetts, a cosmic convergence of money, memorial, and motivation was poised to reshape astronomy forever. Observatory director Edward C. Pickering shared much in common with Draper, including the dream to construct an all-sky spectral catalog. But he was frustrated by the slow progress that his young male assistant was making on analysis of photographic plates. In fact, legend has it that in 1880, Pickering became so fed up with his lackadaisical assistant that he claimed his maid could do a better job. It turns out that he was right.

Fortunately for Pickering, his maid was Williamina P. Fleming (Mina to her friends). Fleming had no formal science education, but having just been abandoned by her husband and raising her infant son alone, she did have a pressing need to become gainfully employed. Going out on a limb, Pickering hired her as a full-time member of the observatory staff in 1881. And Fleming soon found herself knee deep in astronomical data and tackled her newly assigned duties with zeal.

It wasn't as though women had never had a hand in astronomy before Fleming's hiring. Everyone knew about the world-renowned comet hunters Caroline Herschel and Maria Mitchell. Still, despite these and other heavy-hitters, notable women in the field of astronomy were pretty sparse, even as late as 1880.

The lack of female participation in astronomy was not for lack of interest. It was simply thought that long nights in a cold observatory dome were hazardous to the delicate female constitution. Even the sheer emotion of witnessing astronomical phenomena was considered harmful, so much so that Anna Draper was once kept in a tent during a total solar eclipse "lest the vision might unnerve her."

Finally in 1886, under the financial support of the newly founded Henry Draper Memorial Fund (managed by Anna Draper) and the leadership of Pickering, Henry Draper's dream project commenced at HCO. And with that, Pickering soon found himself in desperate need of data analyzers. Himself a proponent of women's rights, Pickering was convinced that his good fortune in hiring Fleming had been no fluke. After all, at the time, women were thought to be somehow naturally suited to repetitive tasks like calculating, tabulating, measuring, and scrutinizing. As an added bonus, they were also less than half the cost of their male counterparts.

News of the generous and hospitable Professor Pickering spread like an expanding supernova shockwave, and eager applicants — replete with every hard-luck story imaginable — converged on Cambridge. Pickering hired whom he could, petitioning various committees for additional funds. The magnitude of the Draper Catalog project was unprecedented, he argued (see "Giving Standards to the Stars," page 48). Answering the riddles of the universe merited more assistants, particularly since Harvard possessed data of unmatched quantity and quality.

His petitions were effective. After 1886, the workrooms at the observatory never held fewer than a dozen computers. A new building — the Brick Building — was eventually constructed specifically to accommodate the photographic plates and the women who would determine their secrets. Over the course of the next thirty-plus years, 45 women found employment at HCO.

But it wasn't a cushy existence for the women computers of HCO. They were expected to work six days a week, seven hours a day (Fleming would later vent in her journal that Pickering's seven-hour day went from 9 A.M. to 6 P.M.) Starting wage was 25 cents an hour. Not bad, but not particularly good, either. For these women, though, the opportunity to be involved with the science they loved was far more important than salary considerations.

Most of the women in "Pickering's Harem" — as the group was rather unflatteringly termed — have faded into obscurity. Pickering was not interested in hiring independent thinkers. He had specific tasks in mind for every woman he hired, and it would have been a loss of productivity for anyone to engage in her own astronomical research. Still, a handful of women shone through.

The first to make a name for herself was, to no surprise, Fleming — Pickering's maid-turned-computer. Despite her lack of scientific background, the early stage of the Draper Catalog project needed someone to classify and organize the information. That's where Fleming first impressed Pickering.

The original appeal of stellar spectra lay in their mystery. The first observations of stellar spectra in the early 1800s hinted to astronomers that there was something significant about the pattern and intensities of the dark lines that chopped the rainbow into slivers. Yet, they simply didn't know what it was. (Visit the magazine page at www.astronomy.com to read more on the-

All photos courtesy Harvard College Observatory

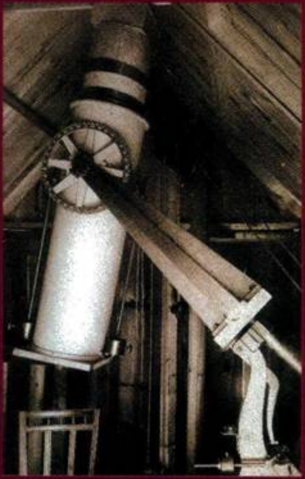
Giving Standards to the Stars

Since astronomers didn't employ uniform observing techniques during the late 1800s, they could not simply pool their accumulating data. But the Henry Draper Memorial changed all of that. Here, for the first time with the Henry Draper (HD) Catalog, data was consistently gathered on homogeneously manufactured and developed photographic plates. A single plate could capture as many as 200 spectra for later analysis — a year's work to the previous generation of astronomers. Multiply hundreds of spectra per plate by a seemingly endless flow of plates, and you get a feel for the magnitude of the Draper Catalog project as it began in 1886.

The enlargements of the raw photographic plates were not the easiest things to deal with. The first order of business was to determine the stellar coordinates, assigning HD numbers to the objects (designations used to this day). Then came the daunting task of identifying spectral features on half-inch-long smears of light and dark stripes. The placement and intensity of the dark stripes needed to be determined precisely in order to properly classify a particular star.

When all was said and done by the middle of the 20th century, Henry Draper's namesake catalog would contain positions and spectral information for nearly a quarter of a million stars.

The Harvard College Observatory women computers at work, directed by Williamina Fleming, standing.



The Harvard computers worked with the spectra gathered with a 8-inch Bache refractor.

The computers included, top row, left to right, Margaret Harwood, who was later appointed observatory director, Mollie O'Reilly, Edward Pickering, Edith Gill, Annie Jump Cannon, Evelyn Leland, Florence Cushman, Marion Whyte, and Grace Brooks; the front row includes Arville Walker, Johanna Mackie, Alta Carpenter, Mabel Gill, and Ida Woods.

electromagnetic spectrum, stellar classifications, and human computers.)

Having already spent a few years demonstrating her administrative, computing and organizational abilities, Fleming soon found herself supervising a platoon of assistants. The directive from their benevolent dictator Pickering was clear: Make some sense of it all.

After four years of tireless, tedious scrutiny, Fleming and her team had managed to classify 10,498 stars with a scheme that the astronomical community coined the "Pickering-Fleming system," a label that indicated the first general recognition of a woman astronomer. This system consisted of 15 spectral classes, each of which had specific identifying features such as the strength of, say, the dark lines corresponding to hydrogen. The classes were given simple letter designations, A through Q (I, J, and P were omitted; all oddities were lumped into Q).

Fleming's work with spectra was so marvelous, in fact, that Pickering later trusted her with virtually every aspect of the astronomical work at the observatory, from doing the science to directing the assistants and editing the publications. She would ultimately become the first woman to earn an official Harvard "corporation" appointment, and her accomplishments paved the way for subsequent achievements by her colleagues and successors.

One of Fleming's successors was Annie Jump Cannon, whose name appears in every introductory astronomy textbook. She was one of the few computers who had training in physics and astronomy, having graduated from Wellesley in 1884. A decade later, after returning home to Delaware, the partially deaf Cannon realized that her heart lay in the stars. "I am sometimes very dissatisfied with life here," reads Cannon's journal. "I do want to accomplish something so badly." It wasn't long before she became one of Fleming's assistants, tackling the growing collection of photographs and spectra.

By the time Cannon came to HCO in 1896, the quality of the spectra had improved greatly. Now instead of a large-scale survey, Pickering's observing team began to focus on obtaining higher-dispersion (i.e. longer and more detailed) spectra of bright stars.

The study of these new and improved spectra was initially assigned to Draper's niece Antonia C. Maury in 1888. But after numerous disagreements with Pickering concerning her desire to understand the subject she was engaged with, Maury ultimately left HCO (see "The Nature of the Stars, page 50).

Cannon took over Maury's work, scrutinizing the spectra with an eye so keen that even decades later she could place a spectrum within one subclass of her original designation. Possessing what her colleagues agreed was a charming personality, this "benign presence of the Brick Building" was arguably the most efficient and well-liked computer Pickering ever hired.

Cannon's classification scheme retained Fleming's original letter designations, but followed the overall sequence of Maury's. By using Maury's sequence, Cannon saw the need to categorize stars according to some unknown physical property. Adopting Fleming's notation avoided complexity.

The result? The familiar O, B, A, F, G, K, M. Seven major classes, each with ten subclasses — 0 through 9 — based on the presence, absence, or intensity of particular spectral features.

"Oh Be A Fine Girl (Guy), Kiss Me" has become the litany of generations of astronomy students as they try to commit this alien string of letters to memory. O stars are hot stars; M stars are relatively cool. The sun is "just right" — a G2 star. The spectral class practically screams out the star's physical properties, including temperature.

Cannon could classify spectra at a stunning rate — hundreds per hour — with incredible accuracy. By the time the Draper Catalog was finished, she had classified 225,300 stars. If that were all she had accomplished, she would have had an unbelievable resume. But Cannon's work in other areas continued with the same intensity until her death in 1941. Another astronomer, Cecilia Payne-Gaposchkin, wrote in Cannon's obituary, "A bibliography of Miss Cannon's scientific work would be exceedingly long … she was a legend."

Annie Jump Cannon, left, and Henrietta Leavitt were among the few human computers at Harvard who had earned college degrees.

This photo of the Harvard College Observatory was taken in 1897 with a pinhole camera.

The length of anyone's resume at the HCO was partially due to the amount of data taken. By the turn of the century, even Anna Draper wondered if it was "advisable to continue to take photographs … night after night."

Fortunately, around the time that Mrs. Draper was getting antsy, another soon-to-be big name was hired on, convincing her that her money was well spent. You can probably also find her name — Henrietta Swan Leavitt — in any introductory textbook. Like Cannon, Leavitt possessed a college degree, a rarity among the computers. She began working at Harvard in 1895, three years after her graduation. Leavitt impressed Pickering immediately, becoming the renowned "variable star fiend" of the observatory.

Leavitt's forte was photographic photometry — determining the absolute brightness of the stars from photographic plates. She could get an accurate photometric magnitude scale with the aid of photography and also perform night-to-night comparisons of stars to ferret out new variables. The technique for variable hunting was strikingly uncomplicated.

Leavitt would simply overlay the positive plate of a region of sky on the negative plate taken on a different night. If the positive and negative star images didn't match up, she would flag a potential variable. She discovered over 2,400 variable stars in this fashion, about half of the ones then known to exist.

But the work that garnered Leavitt the most attention surrounded an educated hunch she had about a particular set of stars called Cepheid variables. She noticed that, "the brighter variables have longer periods." Armed with this information, Leavitt could determine stellar distances, something notoriously difficult at the time. And with that, Leavitt had discovered the now-famous Cepheid period-luminosity relationship that marked the beginning of a revolution in astronomy that would ultimately determine our location in the Milky Way Galaxy and the scale of the universe. To this day, Leavitt's relationship remains a cornerstone of distance determination techniques.

The influence of the women of HCO on astronomy and American history cannot be overstated. Because of individuals like Fleming, Cannon, and Maury, women have remained a constant and ever-increasing presence in professional astronomy and every sphere of American culture since 1880. Their work has inspired generations of astronomers and paved the way for the latest generation of stars.

C. Renée James is an assistant professor of physics at Sam Houston State University.

The Nature of Stars

When Henry Draper's niece Antonia C. Maury came to HCO in 1888, she had high hopes. In just a few months, she created a new, and more complicated, spectral classification scheme — one that would ultimately inspire Danish astronomer Ejnar Hertzsprung and American Henry Norris Russell to discover that spectra actually indicate physical properties of the stars, such as temperature and luminosity. However, Maury's system was complicated, containing unintuitive subclasses. Meanwhile, she defended the complexities, asserting that they indicated something about the actual nature of the stars.

Her attempts at developing a theoretical basis for the new classifications were frowned upon. As far as Pickering was concerned, this was not in her job description.

Disappointed that her theoretical skills were dismissed, Maury abandoned her work at Harvard by 1891. She corresponded occasionally, and even worked voluntarily over the next 40 years, but her main project was left for Cannon to finish. Though women were finding gainful employment in astronomy, Maury's experience indicates that they still had a long way to go before being valued as independent thinkers.

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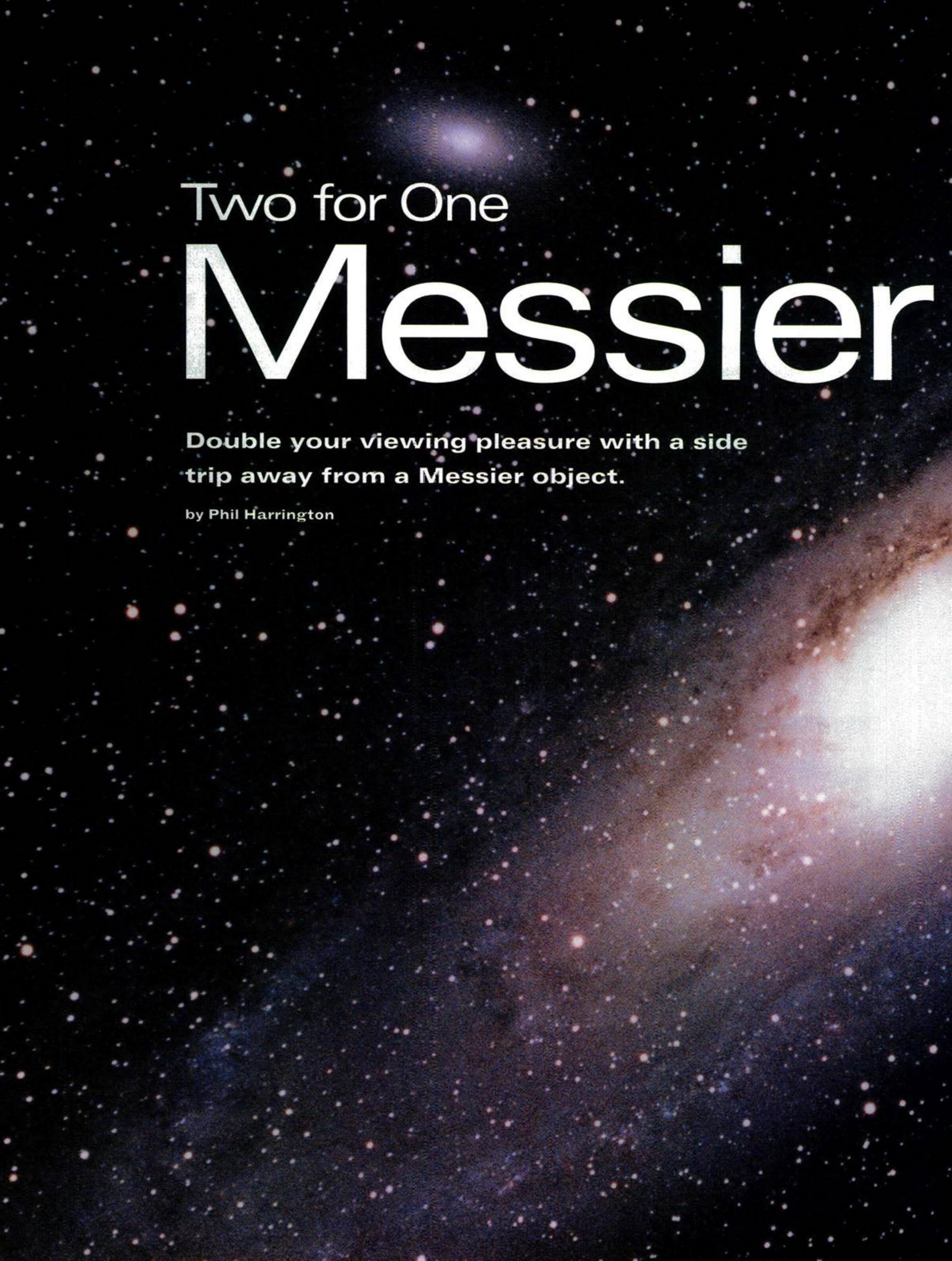

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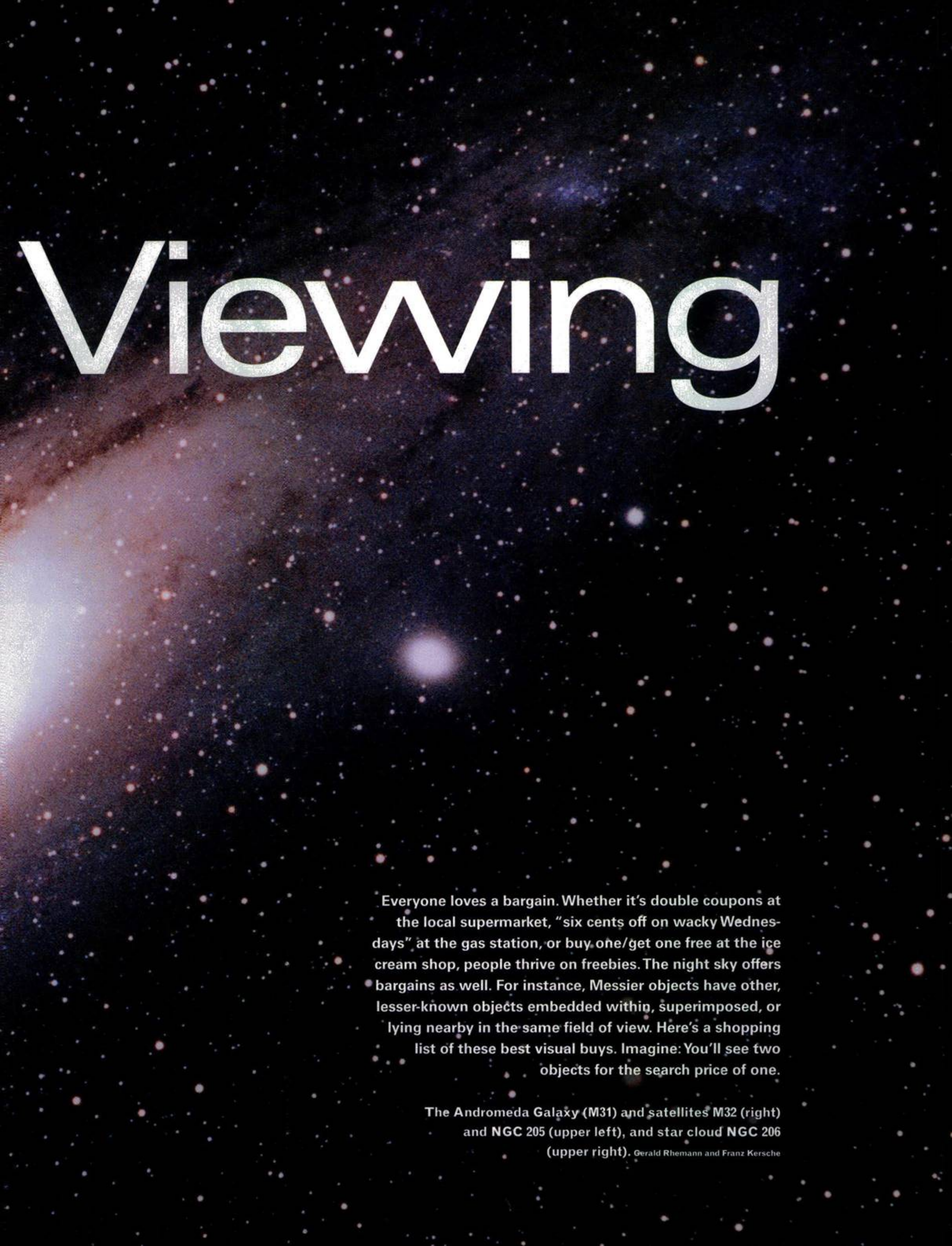


Everyone loves a bargain. Whether it's double coupons at the local supermarket, "six cents off on wacky Wednesdays" at the gas station, or buy one/get one free at the ice cream shop, people thrive on freebies. The night sky offers bargains as well. For instance, Messier objects have other, lesser-known objects embedded within, superimposed, or lying nearby in the same field of view. Here's a shopping list of these best visual buys. Imagine: You'll see two objects for the search price of one.

The Andromeda Galaxy (M31) and satellites M32 (right) and **NGC** 205 (upper left), and star cloud **NGC** 206 (upper right). Gerald Rhemann and Franz Kersche

Messier 7

The open cluster team of M6 and M7 creates one of the prettiest sights in the entire sky. While both are ideal binocular targets, studying the latter through 6-inch or larger telescopes reveals a hidden treasure. Beyond the stars of M7, near the cluster's western edge, is the 10th-magnitude globular cluster NGC 6453. Through a 13-inch reflector, I recorded NGC 6453 as an unresolved smudge of light buried in an ocean of starlight, but spotting it can be like finding a needle in a haystack. A collection of five 12th-magnitude stars are superimposed on the globular, which helps point the way. Use a detailed chart to find this elusive target.

Messier 8

Visible to the naked eye on dark summer nights, the Lagoon Nebula is one of the most famous emission nebulae regions in the sky. As the nebula continues to evolve, portions of it are slowly condensing to form individual stars. We can see this in the shape of an open star cluster buried within the nebula. Cataloged separately as NGC 6530, the circular cluster lies east of the center of M8. About 50 suns are brighter than 13th magnitude, and should be visible through a 6-inch telescope on a clear night.

Messier 13

Within a degree of the Hercules Cluster are not one, not two, but three faint galaxies. The brightest of the lot is NGC 6207, a 12th-magnitude spiral nestled just 28' to the northeast of the heart of the globular. Although it measures only 3.3' by 1.7', NGC 6207 is bright enough to see in 6-inch telescopes under rural conditions.

Use an 8-inch to nab NGC 6196, which is set 51' to the cluster's southwest. Shining at only magnitude 12.8, NGC 6196 is a type S0 galaxy measuring about half the apparent size of NGC 6207.

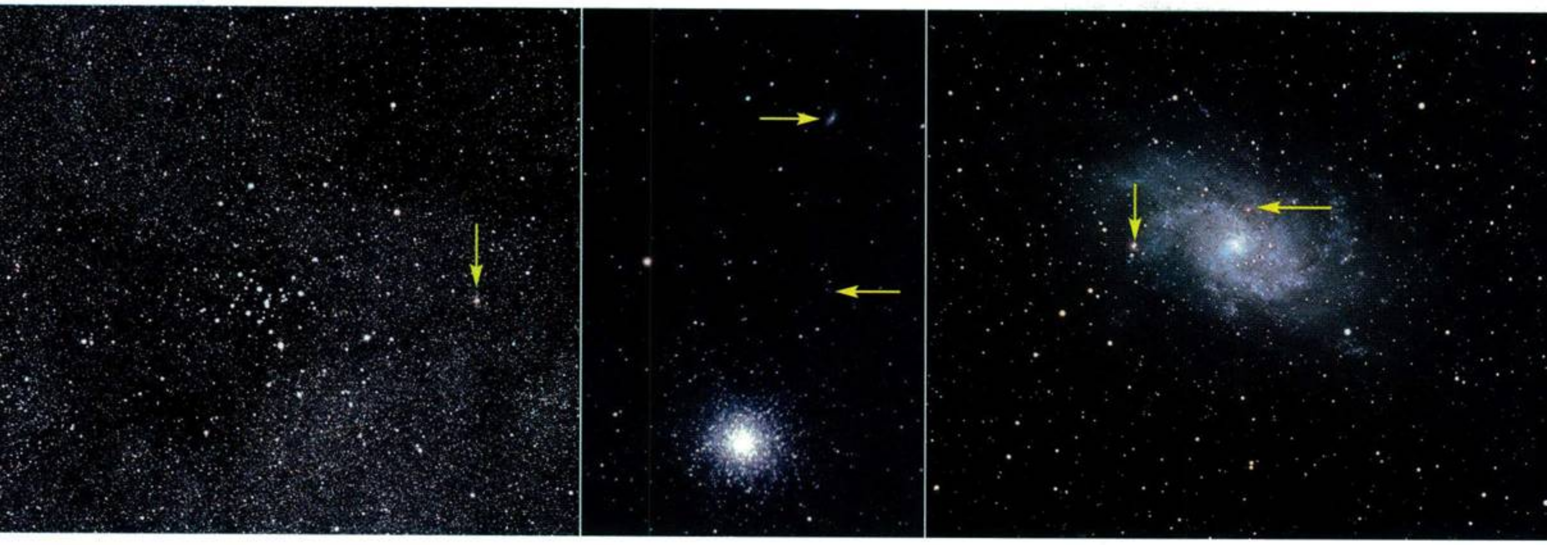
Finally, IC 4617 is the toughest of the three galaxies near M13, but is also the closest to the cluster. The pair is separated by only 15', with IC 4617 to the cluster's north-northeast. This is a difficult catch even with my 18-inch telescope under dark skies. Look for two close-set 11th-magnitude stars just off the cluster's northeastern edge, then move two 13th-magnitude stars even further northeast. IC 4617 appears to touch the westernmost of those two latter suns.

Messier 31

The closest major galaxy to our own, M31, the Andromeda Galaxy, offers an unprecedented view of such a massive system. In addition to the satellite galaxies M32 and NGC 205 (sometimes called M110), many hidden treasures buried within challenge our skills as observers as well as the optical quality of our telescopes.

From the core of M31, slide along the galactic plane about 40' to the southwest, until you arrive at a rectangular brightening. That's NGC 206, an enormous cloud of stars and nebulosity within M31 that spans nearly 3,000 light-years. From our vantage point, NGC 206 shrinks to only 2' by 1', but remains bright enough to be seen through 6-inch instruments. You'll find that medium- and high-power eyepieces offer the best view through your scope.

Experienced deep-sky observers with 12-inch and larger telescopes can also spot no fewer than five of M31's family of globular clusters. The brightest, indexed as G1, is positioned about 2.5° to the southwest of M31's central core. To find it, scan south of M31 to the star 32 Andromedae, and then head due west for 1.4°, past a square of 9th-magnitude stars to a lone point.



Left to right: The 10th-magnitude globular cluster NGC 6453 (arrow) is located to the right of open cluster M7. Luke Dodd**; Above and to the right of M13, spot 12th-magnitude NGC 6207 (upper arrow), then search for the very faint IC 4617 closer to M13.** Jeffrey L. Jones**; You'll find NGC 604 (left arrow) as a soft blur on the northeastern fringe of M33's spiral-arm halo, while NGC 595 (right arrow) is practically embedded in its center.** Carl Weber III and Chris Weber.

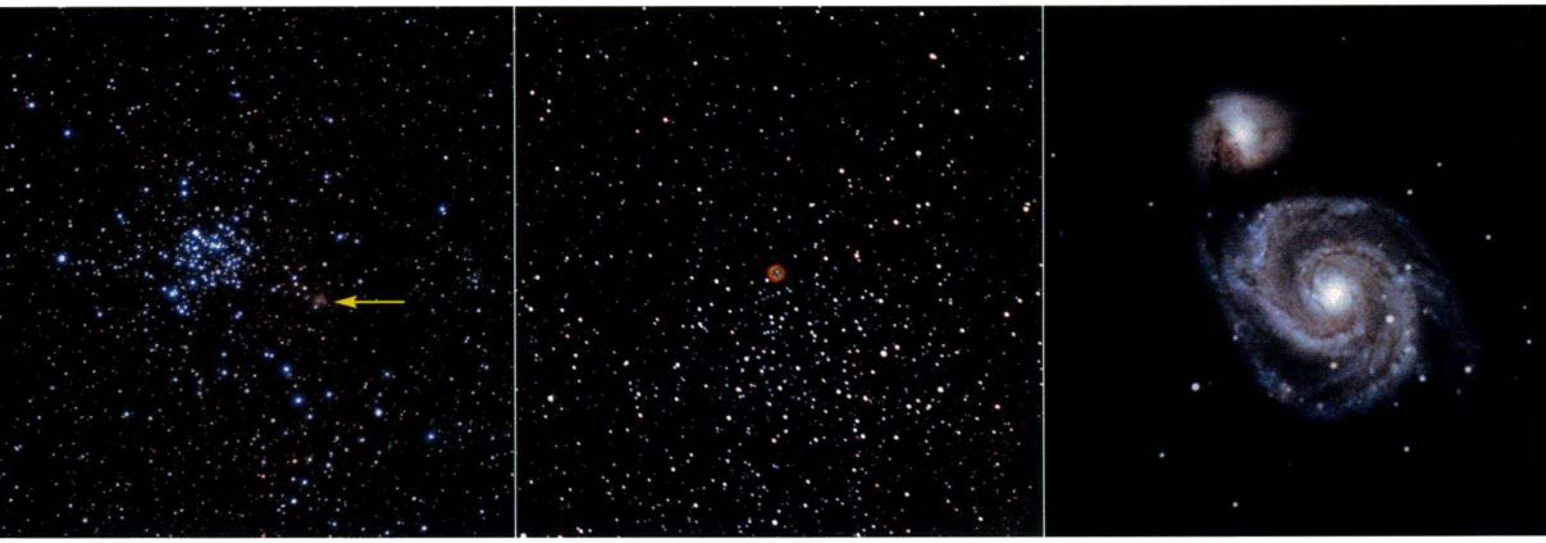
Center that star in your telescope's field, then look about 12' west for a tiny triangle of 13th-magnitude stars. G1 lies just to their south and looks like a fuzzy object about 10" in diameter, marking the center of a very dim "triple star."

Messier 33

The greatest challenge offered by M33, like many other objects, is simply seeing it. But as an observer's eye becomes more accustomed to its appearance, M33 begins to yield riches unsurpassed in any other galaxy north of the celestial equator. A careful search of the spiral-arm halo will reveal numerous bright pockets. Many of these are either large regions of bright nebulosity or clouds of stars within that distant island universe, and carry separate *NGC* and *IC* designations.

The easiest of the bunch to spot is NGC 604, which stands out surprisingly well even with a 3-inch telescope. Look for a soft blur northeast of the galaxy's core. For the best view, switch to high power.

Another patch, NGC 595, lies to the west of the galaxy's core, and is more difficult to pick out.



Left to right: From Earth's perspective, M35 appears to dwarf NGC 2158 (arrow) to its lower right; however, the latter actually contains more stars than its closer cousin. Sheldon Faworski; **Star cluster M46 and ring-like NGC 2438 look close in this image, but are nowhere near each other in space.** Joe F. Gafford; **The arms of spiral galaxy M51 reach out to embrace NGC 5195.** Bill and Sally Fletcher.

Messier 35

M35 is one of my favorite winter star clusters, both for its inherent beauty and for its distant cousin, NGC 2158, set about half a degree to the southwest. Although bright enough to be visible through 4-inch telescopes, NGC 2158 needs at least a 6-inch to resolve its brightest stars, which shine at only 12th magnitude. Although it contains more stars, NGC 2158 appears much fainter than M35 because it is so much farther away. In fact, NGC 2158 lies nearly 16,000 light-years from us, placing it close to the outer fringes of our galaxy. M35 is a comparatively close 2,800 light-years.

Messier 46

Open cluster M46 in Puppis is a striking sight through just about any telescope, with more than 500 dim stars crammed into an area 27' across. When viewing M46 through a 6-inch or larger telescope, look for a tiny, grayish disk among the stars in the northern part of the cluster. That is the 10th-magnitude planetary nebula NGC 2438. It can be a tough catch because of its small size, so be sure to use between 150x and 200x to pick it out.

Appearances to the contrary, the cluster and nebula are nowhere near each other in space. M46 is 5,400 light-years away, while NGC 2438 is only about 2,900 light-years from Earth.

Messier 51

At first glance, M51 — the famous Whirlpool Galaxy — looks a little lopsided. Rather than appearing round, like most other face-on spirals, M51 has a lump protruding from its northern edge. That bulge is actually another galaxy, NGC 5195.

A 3-inch telescope or steady, 10x binoculars will immediately show this second, irregular galaxy. Six-inch and larger instruments add a luminous arm extending from M51, seemingly reaching out to embrace NGC 5195.

Messiers 81 and 82

Each with its own unique personality, M81 and M82 are favorite galaxies for backyard astronomers. And if they don't capture your attention, there are three other galaxies in the area.

NGC 2976, an oval-shaped spiral characterized in photographs by its wide arms, lies about 1.4° to the southwest of M81. Six-inch and larger telescopes allow you to make out its faint presence.

Then, there is NGC 3077, set about 45' to the east-southeast of M81, near an 8th-magnitude star. A 4-inch or larger telescope shows its dim disk as a soft glow.

Finally, NGC 2959 is west of M81, positioned just south of two 10th-magnitude stars. Rated at only magnitude 14, this galaxy is visible in a 12-inch or larger telescope.

Messiers 84 and 86

Found right at the heart of Coma-Virgo Realm, M84 and M86 are separated by only a third of a degree and are surrounded by several faint galaxies within the grasp of an 8-inch telescope. For instance, 12th-magnitude NGC 4387, a tiny elliptical, is just 11' to their south, while NGC 4388 — an 11th-magnitude edge-on spiral — is located a little farther south still. Together, these four galaxies resemble a giant intergalactic happy face. M84 and M86 mark the eyes, NGC 4387 the nose, and NGC 4388 the thin mouth.

But wait, there's more. Ten arcminutes north of M86 is the edge-on spiral NGC 4402. The barred spiral NGC 4413 lies 21' to M86's south. Rounding out the group is NGC 4425, 20' southeast of M86. If that weren't enough, other targets within only a few degrees make this an amazing area to explore.

So start your deep-sky shopping list with these, then add your own bargains for the most visual bang for your observing buck. See *astronomy.com* for a complete Messier vicinity objects list. ▣

Phil Harrington started his virtual "shopping trips" to the stars decades ago. Visit his website at www.philharrington.net.

sky Show

july

Goodbye planets, hello Milky Way.

by Martin Ratcliffe and Alister Ling

The curtains are about to close on the great planet show of 2002. Venus remains the sole evening star, gradually sinking into the encroaching twilight. On its inside orbital track, Venus begins to slip between Earth and sun, and next month will drop out of sight. Even under those stagnant, humid air masses of the East Coast, you should still be able to see the changes in Venus's phases from gibbous to an almost half-moon form.

Mercury shoots right past Saturn on the morning of July 2, at least from Earth's vantage point. Close approach occurs about 7 A.M. EDT, when the two will be only a half-moon's width apart. The deeper south you are, the better chance you'll have of seeing this event. The pair will appear low in the northeast at about 4 A.M. EDT, but you'll need a scope to follow the duo after 5 A.M. EDT.

Unlike the equinox and solstice, the media tend to ignore the arrival of Earth at aphelion — it's the farthest point from the sun. This year it happens at midnight on July 5/6. It's just a coincidence that the Northern Hemisphere's summer occurs when Earth is at aphelion. In about 12,000 years, though, the northern summer will occur when Earth is closest to the sun, or at perihelion — turning up the heat on global warming. Larger landmasses in the Northern Hemisphere heat up faster than the Southern Hemisphere and its preponderance of oceans.

The Northern Hemisphere's long summer nights often seem endless for Europeans and Canadians. With sunsets after 10 P.M., and a lazy slide into twilight all night, a delicate phenomenon will sometimes lace the sky with whorls rarer than the northern lights. Noctilucent clouds form at a height of 50 miles (80 km) from tiny amounts of water vapor condensing on meteoric particles.

Meteoric debris constantly rains down on us as Earth sweeps up interplanetary dust while orbiting the sun. By month's end, we run into a slightly denser stream of dust, the particles of which streak across the sky as the Southern Delta Aquarid meteor shower.

Above: The Milky Way stretches high above Arizona's Superstition Mountains. Frank Zullo
Right: Try some daytime lunar observing from high atop the Sierra Nevadas. Jim Baumgardt

Unfortunately, the bright gibbous moon may hide from view many of the showers' fainter streaks.

Camping offers a perfect opportunity to relax and look up at the stars. The big band of light arching across the east and rising higher into the night is none other than the Milky Way — our home galaxy seen edge-on from the inside.

Let's do some daylight lunar observing. Grab your binoculars and watch the left limb of the moon during the last days of June and first week of July. Toward the lower left of the moon's disk is a small dark oval — a lava-filled crater called Grimaldi. As each day passes, you will see it slightly farther from the limb. At this time we see a bit farther around the left side of the moon than usual.

The delightful comet Ikeya-Zhang that sparked our spring skies is now heading back south toward the outer reaches of the solar system on its 342-year orbit around the sun. Calculations show that this fuzzy snowball can be retraced back to a bright comet seen in 1661. As it fades, it passes near the bright globular cluster M5. New comets are discovered every few days. Maybe the next bright one will arrive soon, just like the surprising Ikeya-Zhang.

July 2002

1 Asteroid Hebe is at opposition, 4 P.M. EDT

2 The moon is at apogee (251,164 miles from Earth), 3:35 A.M. EDT
Mercury passes 0.2° south of Saturn, 7 A.M. EDT (page 63)
Last quarter moon is at 1:19 P.M. EDT

3 Mars passes 0.8° north of Jupiter, 2 A.M. EDT

4 Mars passes 6° south of Pollux, 1 P.M. EDT

5 Earth is at aphelion (94.5 million miles from the sun), midnight EDT

8 The moon passes 1.7° north of Saturn, 9 A.M. EDT

10 Venus passes 1.1° north of Regulus, 6 A.M. EDT
New moon is at 6:26 A.M. EDT

13 The moon passes 4° north of Venus, 8 A.M. EDT

14 The moon is at perigee (228,570 miles from Earth), 9:21 A.M. EDT

17 First quarter moon is at 12:47 A.M. EDT

19 Jupiter is in conjunction with the sun, 9 P.M. EDT

20 Mercury is in superior conjunction, 10 P.M. EDT

21 Asteroid Amphitrite is at opposition, 11 P.M. EDT

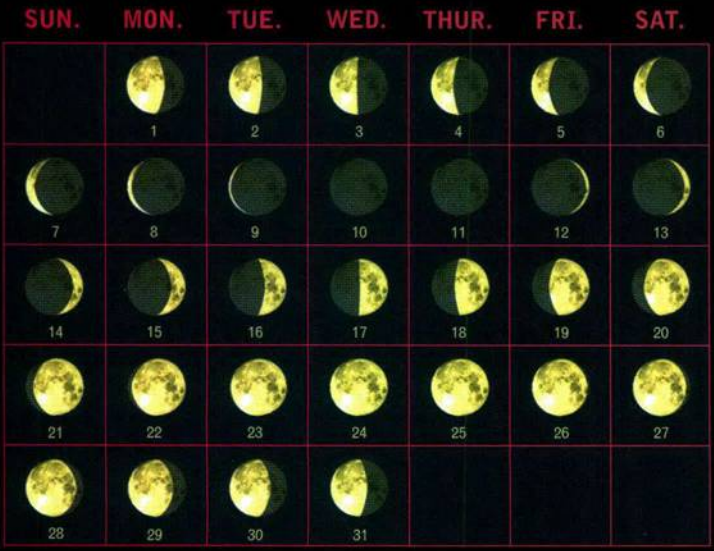
23 Asteroid Vesta is in conjunction with the sun, 4 A.M. EDT

24 Full moon is at 5:07 A.M. EDT
The moon passes 4° south of Neptune, 7 P.M. EDT

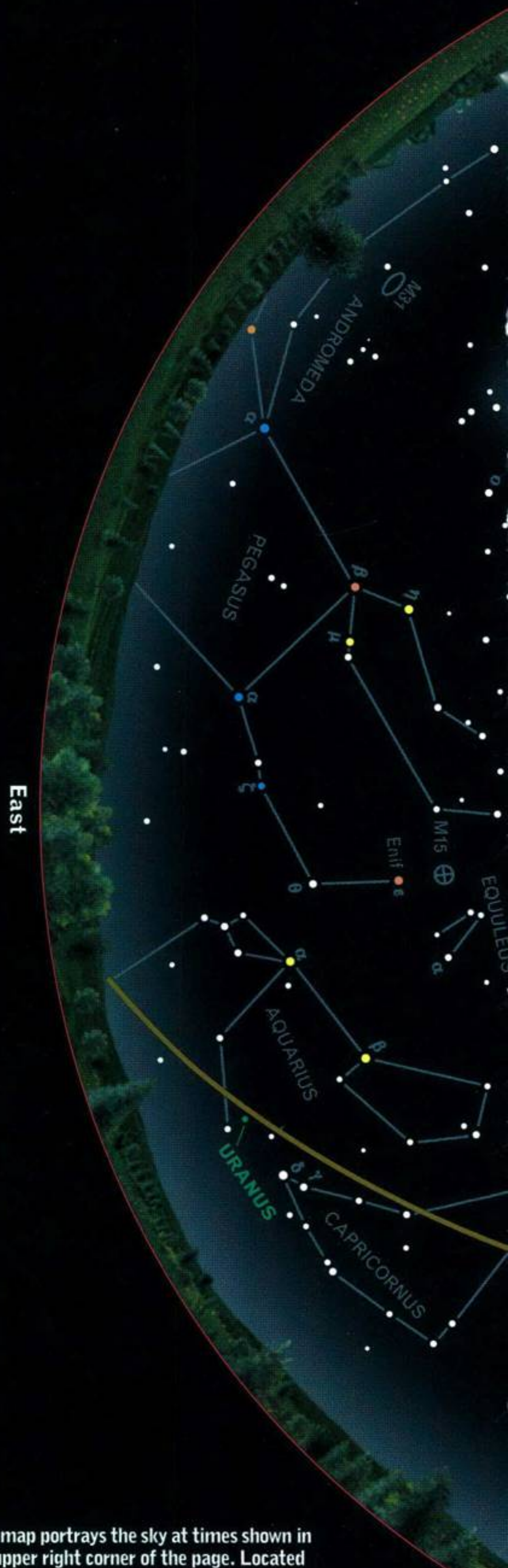
26 The moon passes 4° south of Uranus, 5 A.M. EDT

28 Southern Delta Aquarid meteor shower peaks (page 64)

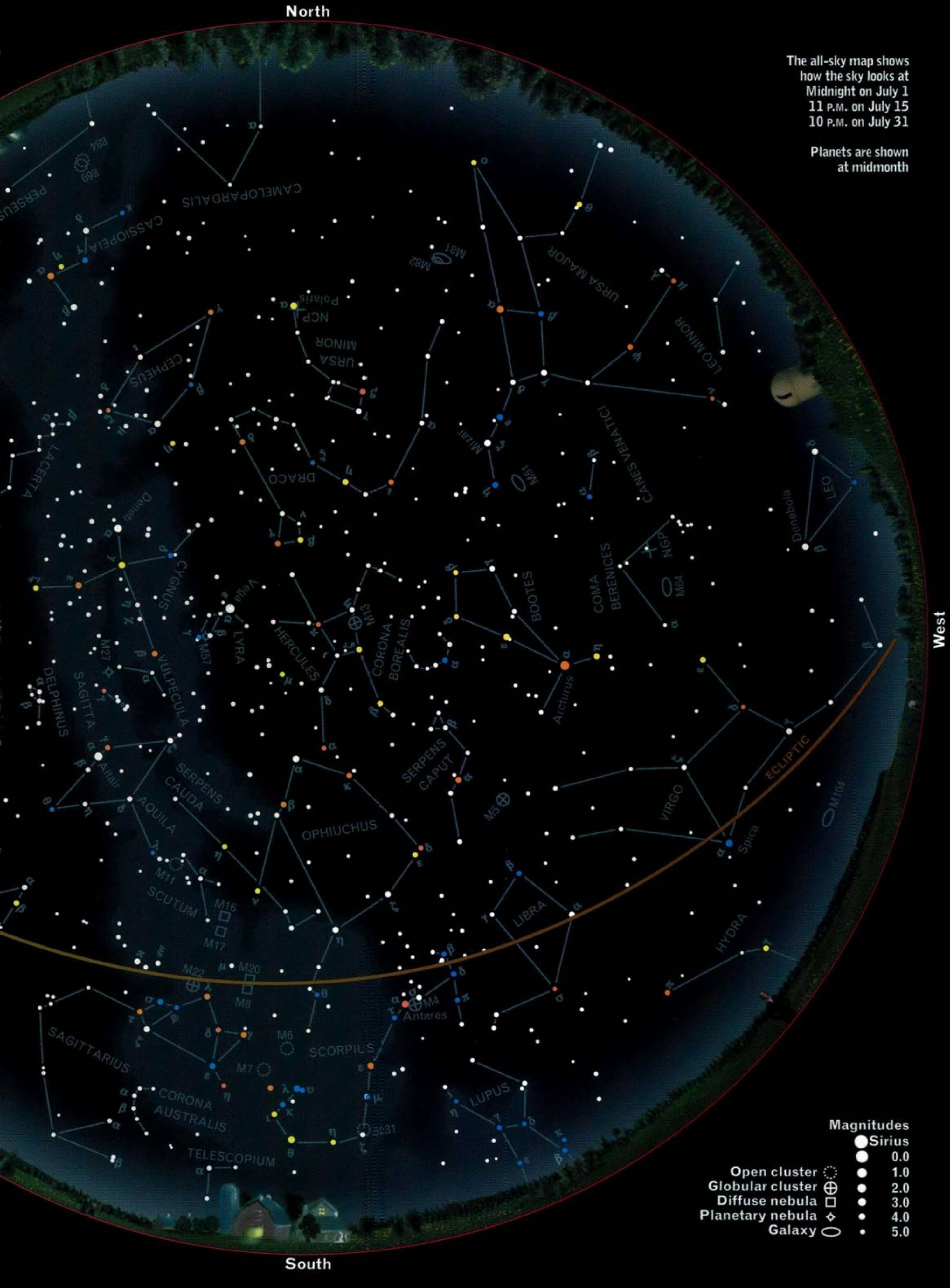
29 The moon is at apogee (251,496 miles from Earth), 9:43 P.M. EDT



SUN.	MON.	TUE.	WED.	THUR.	FRI.	SAT.
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			



This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

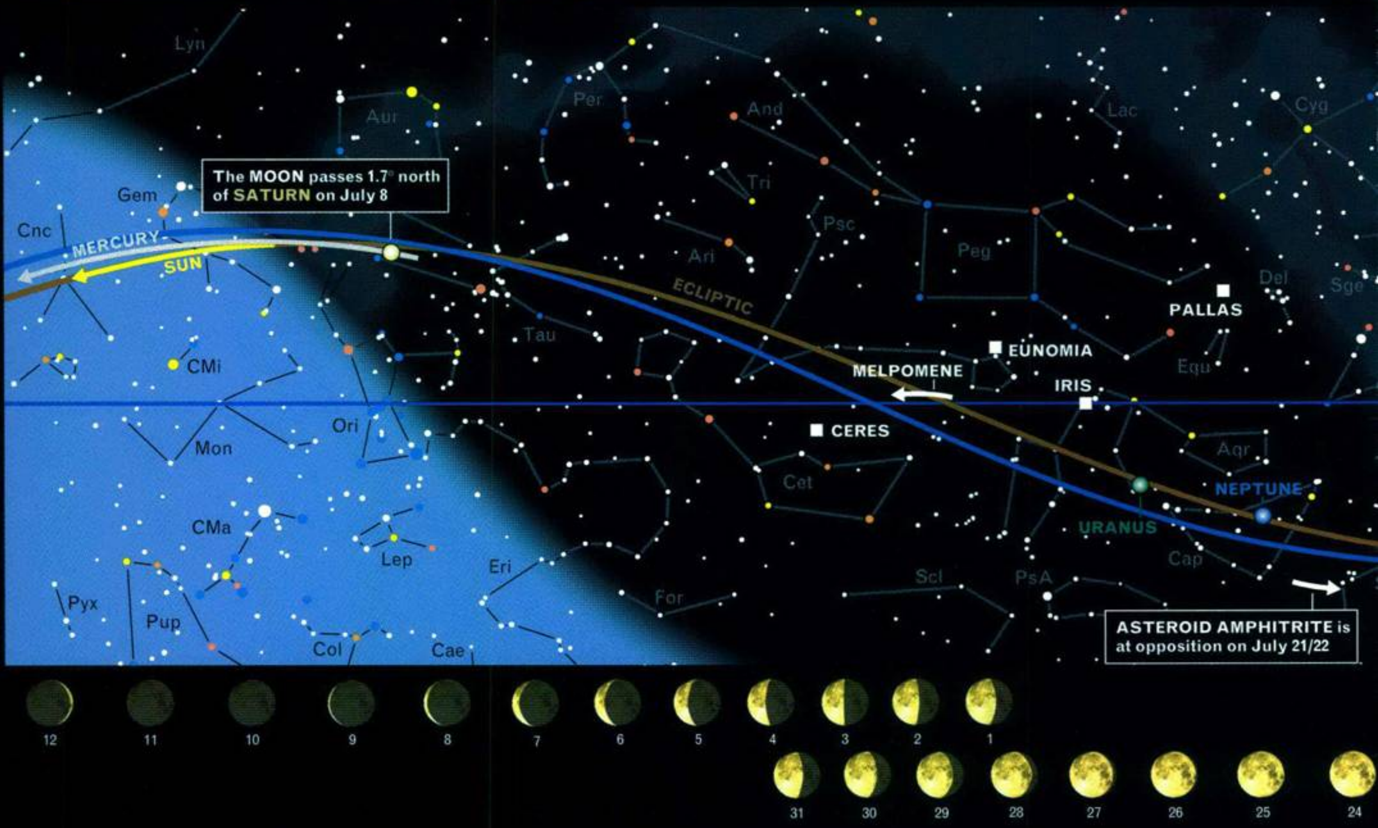

North
West
South
PERSEUS
884
869
CAMELOPARDALIS
CASSIOPEIA
URSA MAJOR
M81
M82
Polaris
NCP
URSA MINOR
LEO MINOR
CEPHEUS
DRACO
Mizar
M51
CANES VENATICI
LACERTA
Deneb
LEO
Denebola
NGP
COMA BERENICES
M64
CYGNUS
Vega
LYRA
M57
HERCULES
M13
CORONA BOREALIS
BOOTES
Arcturus
M27
DELPHINUS
SAGITTA
VULPECULA
Altair
SERPENS CAUDA
AQUILA
SERPENS CAPUT
M5
OPHIUCHUS
VIRGO
ECLIPTIC
M104
Spica
M11
SCUTUM
M16
M17
LIBRA
HYDRA
M22
M20
M8
M4
Antares
SAGITTARIUS
M6
SCORPIUS
M7
CORONA AUSTRALIS
LUPUS
3231
TELESCOPIUM
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
Midnight on July 1
11 P.M. on July 15
10 P.M. on July 31

Planets are shown
at midmonth

Path of the Planets

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects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MERCURY
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PALLAS
Tau
EUNOMIA
CMi
MELPOMENE
IRIS
Equ
Ori
CERES
Mon
Aqr
Cet
NEPTUNE
URANUS
CMa
Lep
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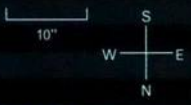
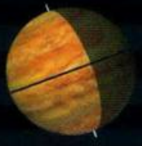
The **MOON** passes 1.7° north of **SATURN** on July 8

ASTEROID AMPHITRITE is at opposition on July 21/22

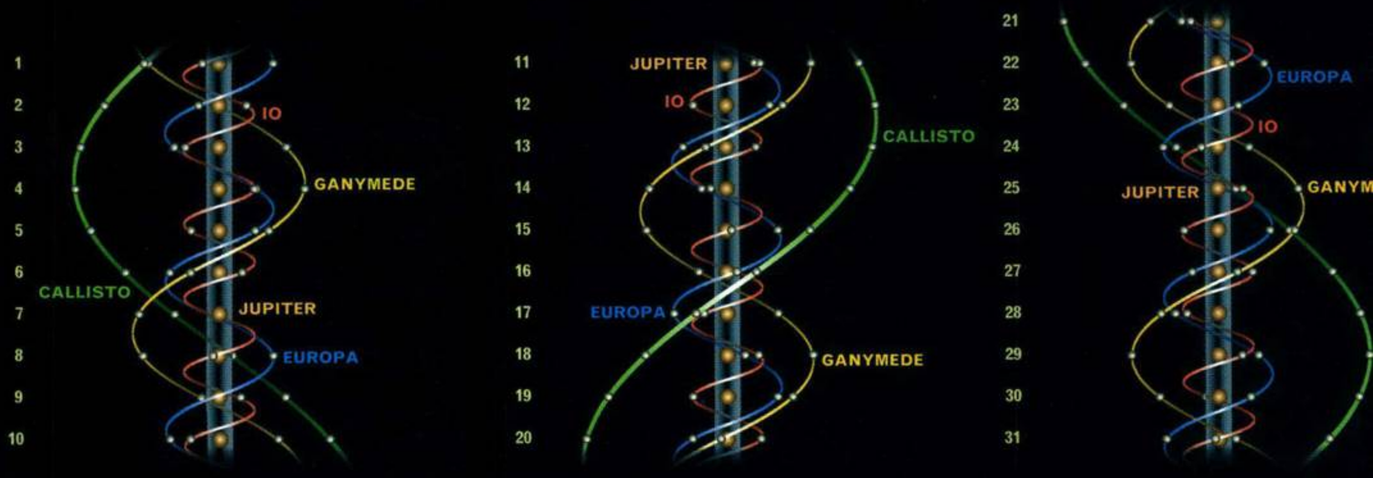


PLANETS	**MERCURY**	**MERCURY**	**VENUS**	**MARS**
Date	July 1	July 31	July 15	July 15
Magnitude	−0.3	−1.0	−4.1	1.8
Angular Size	6.6″	5.1″	16.9″	3.5″
Illumination	60%	93%	66%	100%
Distance (AU) from Earth	1.027	1.317	0.988	2.642
Distance (AU) from Sun	0.354	0.372	0.724	1.644
Right Ascension (2000.0)	5h13.1m	9h25.1m	10h27.8m	8h13.3m
Declination (2000.0)	21°12′	16°58′	11°01′	21°04′

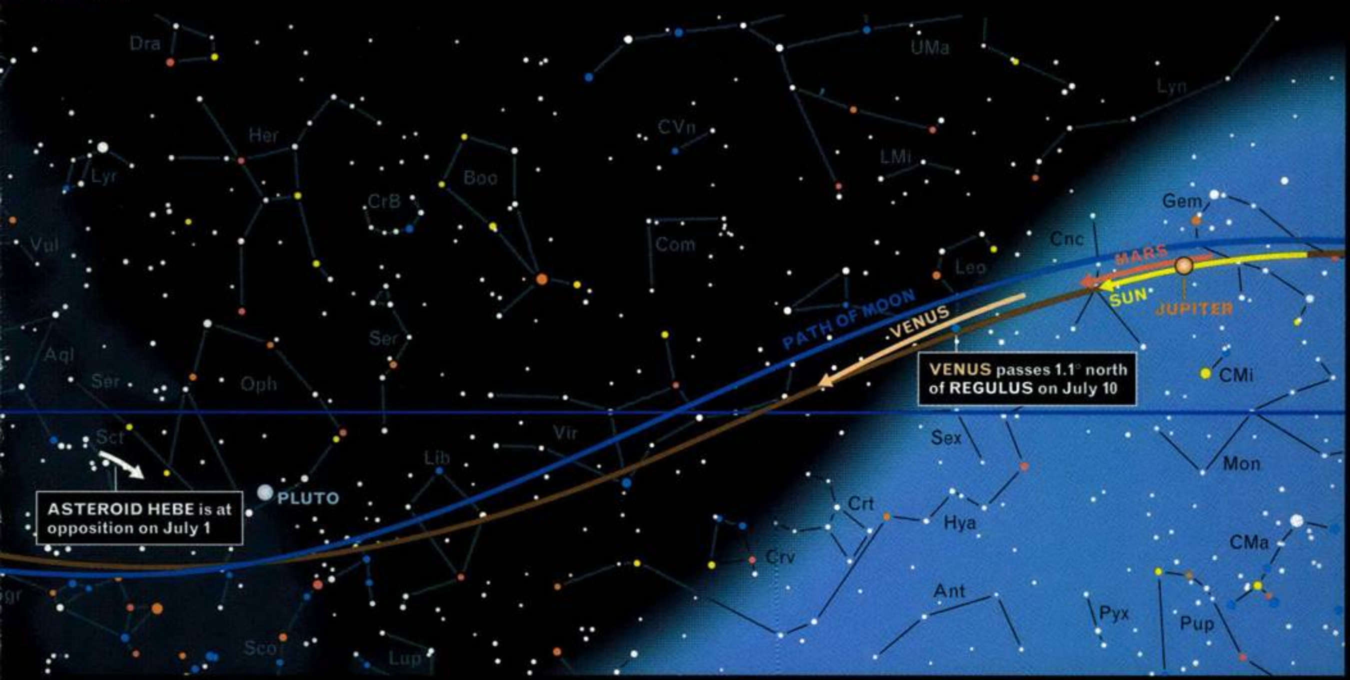


Jupiter's Moons

Dots display positions of Galilean satellites at 10 P.M. EDT on date shown. South is at top to match the view in a telescope.



during the month.



Dra
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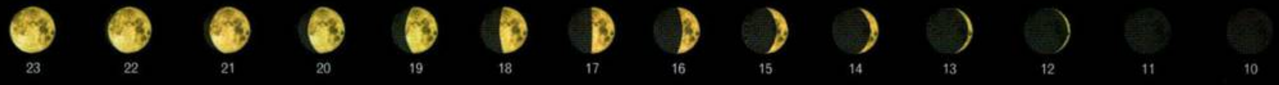
SUN
JUPITER
PATH OF MOON
VENUS
Ser
Aql
Ser
Oph
CMi
Sct
Vir
Sex
Lib
Mon
PLUTO
Crt
Hya
Crv
CMa
Ant
Pyx
Pup
Sco
Lup

VENUS passes 1.1° north of **REGULUS** on July 10

ASTEROID HEBE is at opposition on July 1

To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.



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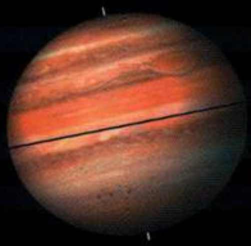


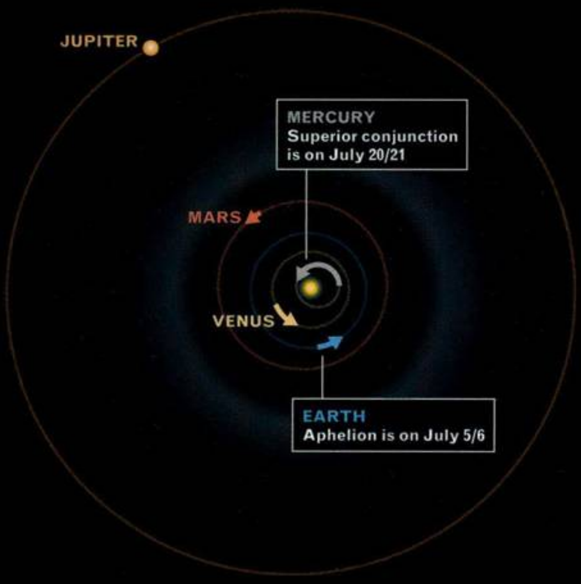
JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
July 1	July 15	July 15	July 15	July 15
–1.8	0.1	5.7	7.8	13.8
31.7"	16.8"	3.7"	2.3"	0.1"
100%	100%	100%	100%	100%
6.218	9.916	19.170	29.120	29.726
5.237	9.045	20.003	30.090	30.531
7h39.2m	5h29.4m	22h02.3m	20h49.8m	17h00.7m
21°46'	21°59'	–12°51'	–17°40'	–12°41'

The Planets in Their Orbits

Arrows and dots show planets' positions during the month.

EDE

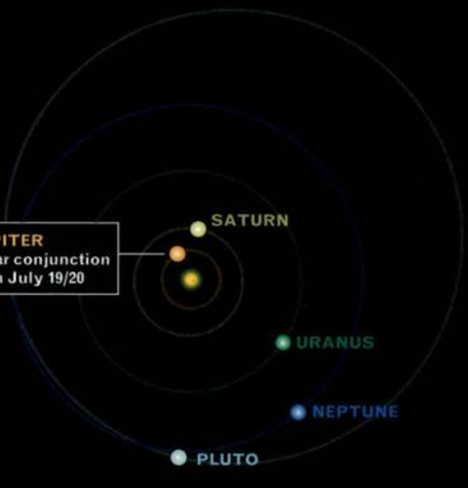
CALLISTO



JUPITER
MARS
VENUS

MERCURY Superior conjunction is on July 20/21

EARTH Aphelion is on July 5/6



SATURN
URANUS
NEPTUNE
PLUTO

JUPITER Solar conjunction is on July 19/20

Great Balls of Stars

Snaking beneath the crown of Corona Borealis, the sinuous path of stars in Serpens floats in front of the transition zone between galaxy country and the so-called globular zone. To the right lie Virgo and the realm of the galaxies, while to the lower left we can peer off toward the center of our galaxy.

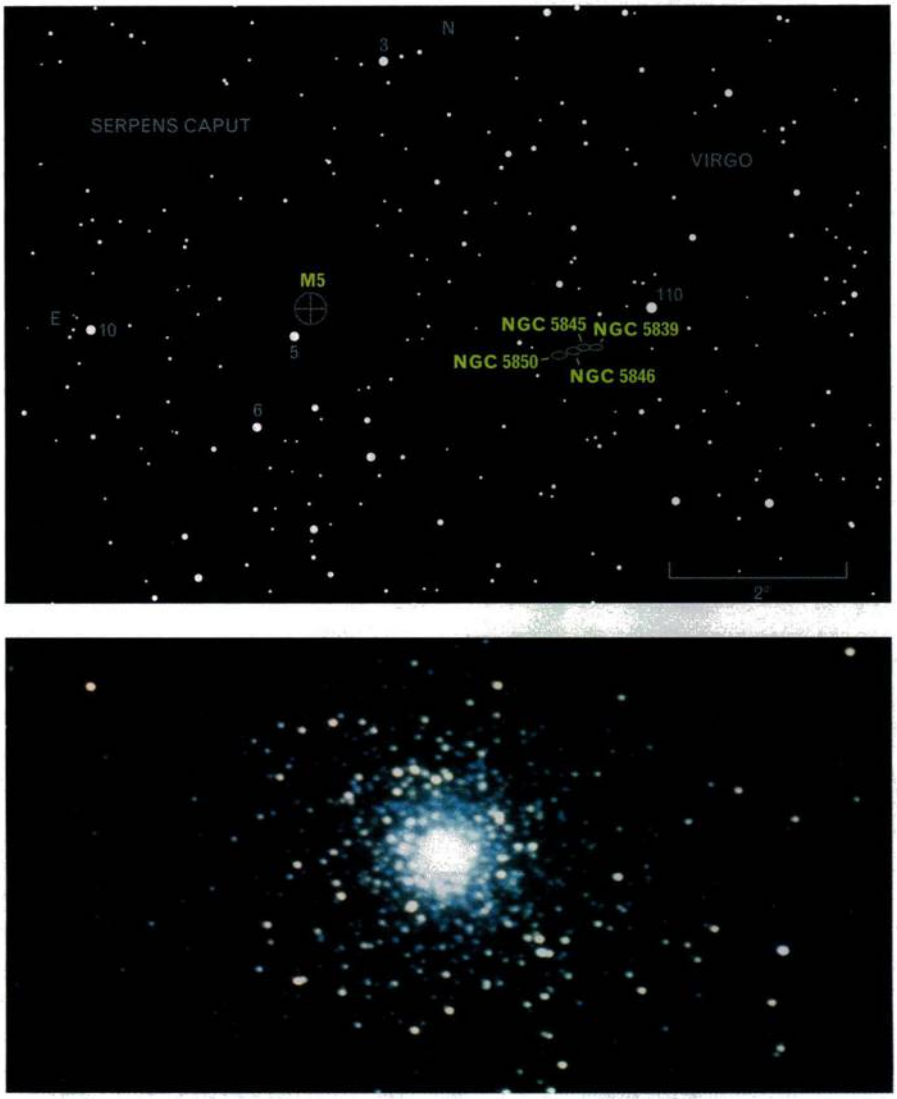
There's an old astronomy pun: Serpens Caput is the constellation of the dead snake. In reality, though, it's anything but dead. In fact, Serpens is home to the brightest globular cluster in the northern sky: M5 (NGC 5904).

It may come as a surprise to some observers, but M5 actually takes top spot in brightness for the Northern Hemisphere, edging past the Hercules Cluster (M13). Glowing at magnitude 5.7, M5 appears as a hazy spot from a dark sky. Messier scores his points for enduring through history, but another astronomer, Gottfried Kirch, first documented M5 on May 5, 1702. He also discovered M11, the Wild Duck Cluster.

Binoculars immediately show M5 as a diffuse cottonball, but a modern 4-inch scope is necessary to pull in the brightest of its supergiant stars. Back in the early 1700s telescopes were not sharp enough to resolve the cluster into its million stars. A good 8-inch scope will show stars pouring out of the field if you can crank the power past 300x. Take some time to observe the chains of stars and the bright center. Then swing up to M13 and compare details at similarly high power.

A classic 60mm refractor will have no trouble splitting the lovely double star Delta (δ) Serpentis. Some observers report the pair as yellowish, others closer to white. The stars are each a bit hotter than our sun. Right now, the 5.2 magnitude secondary star lies about 4.5" from the magnitude 4.5 primary. The stars will slowly separate for another 300 years, then begin closing in on each other again as part of a 3,200-year cycle.

While you are in a star-hopping mood, pop northward to Beta (β) Serpentis, the neck of the snake, then head west (right) to S Serpentis, a pulsating red giant star. If predictions are right, you should see a nice orange spark glowing at about 9th magnitude. To enjoy the color, you'll need at least a 5-inch scope.



M5 in Serpens Caput is the brightest globular cluster in the northern sky. Ben Mayer

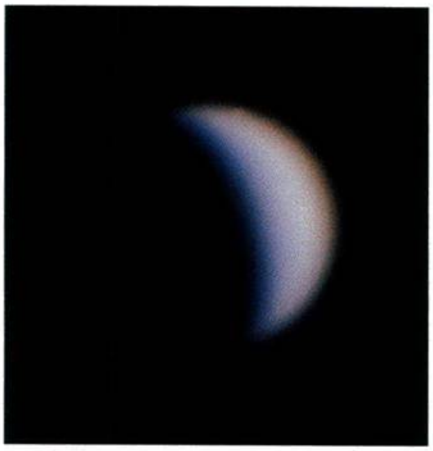
Just across the border in Virgo you can find a nice variety of galaxies, ranging from easy to very difficult to capture. One of the brightest that just missed making the Messier list is NGC 5846, a magnitude 10 elliptical galaxy similar to M87. Its diffuse glow brightens toward the center, 3° west of M5. It's an easy target for a 4-inch scope from dark skies.

Only 10' east, one-third of the moon's apparent diameter, is the nearly edge-on spiral NGC 5850, glowing at magnitude 10.8. This should be a challenging object in a 4-inch scope, but will be a cinch in an 8-inch. Make sure you employ at least 150x — otherwise NGC 5850 will disappear in the field of stars.

Some objects only get noticed at high power, such as NGC 5846A. This tiny elliptical galaxy almost hides in the southern part of its parental glow, just 0.7' south of the core of NGC 5846. Can you see it with a 10-inch scope? Move up to at least 250x.

Forming almost an equally spaced straight line from NGC 5850 back westward through NGC 5846 are two more galaxies: NGC 5839 and NGC 5845. Although a bit fainter than NGC 5846A, they aren't drowned out by the glow of a big elliptical galaxy.

The past two months saw the drama of brilliant planets exchanging places in the evening sky. July opens without as much fanfare on the planetary scene. Jupiter departs from heavenly view, leaving the solitary planet Venus in the evening sky. The dimmer planets Uranus and Neptune are easy to spot in binoculars, though you'll have to wait until the middle of the night to view them. In the morning sky Mercury and Saturn make a brief appearance as a performing duo in the closest appulse of the year.



Left: The changing phases of Venus make for an extraordinary planetary target. Stephen Reed

Let's start with the first visible planet in the evening sky after sunset. **Venus** hangs near Leo's bright star Regulus during July. Venus and Regulus fit within the same low power telescopic field of view on the American evenings of July 9 and 10, when only 65' (a little over one degree) separates the pair.

Regulus is one of four 1st-magnitude stars that, if the circumstances are right, the moon will occult. While an occultation doesn't occur this time around, the slender crescent moon passes north of Regulus and Venus between July 12 and 13. On the evening of July 12 the moon stands less than 6° north-northwest of Regulus. The following night, July 13, the thicker crescent stands 7° east of Venus. Observers in Asia will see the moon and Venus separated by 3° during the local evening of July 13.

Through a telescope, Venus represents a fine chance to view some fascinating changes over a period of time. You can watch its changing phase and increasing size over the next few months as it orbits the sun. Make a brief drawing of what you see each night. Its gibbous phase of 71 percent on July 1 shrinks to 60 percent by month's end. At the same time, the size of Venus grows from 15" to 19". Comparing your drawings over a period of weeks will reveal these changes. These simple observations of an ever-changing Venus are easily explained by the fact that the planet circles the sun inside Earth's orbit. It was not so easy to convince the populace of this seemingly simple fact following Galileo's first view of Venus through his telescope in the year 1610. The concept of a sun-centered solar system was quite new to the masses of the day. Most people had been raised with an Earth-centered view, which maintained a firm separation between the predictions of the mathematical world and the reality seen in the newly invented telescope.

A big challenge this month comes from spotting **Jupiter** and **Mars**. You'll need a perfectly clear western horizon to catch the pair shortly after sunset. Only 49" separate the pair on the evening of July 2. A telescope is required to pick out the magnitude 1.8 Mars in the bright twilight. Jupiter, however, still shines at magnitude –1.8, although it will probably require some type of optical aid to spot. On the evening of July 2 the pair of planets lies approximately 4° above the west-northwestern horizon at 9:15 P.M. local time, which corresponds to approximately 30 minutes after sunset for observers at a latitude of 40° north.

Once Venus sets, the only planetary target on view is **Pluto**. Whether you consider Pluto a challenge or not will depend on the instrumentation you use and the quality of your observing site. Dark sites combined with a sensitive CCD camera will pick up Pluto quite easily. A telescope larger than 12 inches will find Pluto with relative ease under the same conditions. Pluto represents much more of a challenge when viewing from more mediocre observing sights with medium- to small-sized telescopes.

Pluto passed opposition on June 7 and now glows dimly at magnitude 13.8.

Venus and a close crescent moon adorn the summer sky above this rural home. Terry Mann

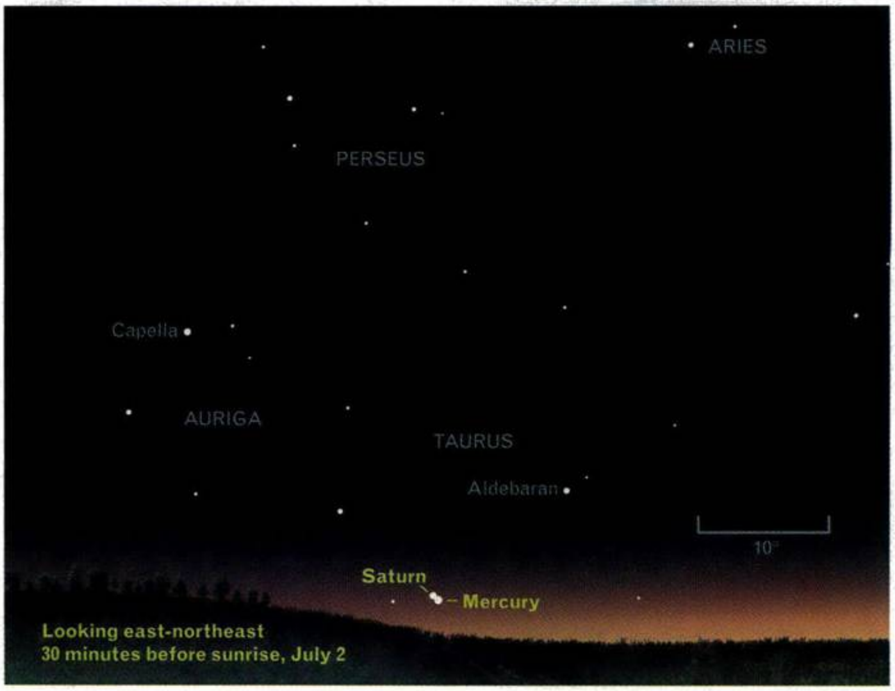
It currently stands amid a rich region of sky filled with faint stars. Eta (η) Ophiuchi, a magnitude 2.4 star in southeastern Ophiuchus, is useful for acquiring the correct starfield. Pluto lies 2.4° north-northeast of this star. Weekly comparisons of the starfield should disclose Pluto's identity by its apparent motion relative to the stationary background starfield. Pluto is visible all night.

Uranus and **Neptune** are clear of the southeastern horizon by midnight. Neptune rises first among the stars of Capricornus the Sea Goat. At magnitude 7.9, Neptune represents a tough target in binoculars unless you have a good guide chart to help you identify it. Look for Neptune between the stars Upsilon (υ) Capricorni and 19 Capricorni. On July 19 Neptune lies due north of a magnitude 6.2 star. Neptune will reach opposition on August 2.

Following Neptune's rise above the eastern horizon is Uranus, which arrives just an hour later. Now in Aquarius, Uranus is currently moving on a retrograde loop that will carry it back into Capricornus one last time. A retrograde, or westerly, track relative to the background starfield is a result of Earth's movement as it begins to overtake Uranus as we orbit the sun. The planet shines two magnitudes brighter than Neptune and is easy to spot in binoculars. You can find Uranus glowing at magnitude 5.8 and lying just 1.5° northwest of the magnitude 4.2 star Iota (ι) Aquarii. The planet will reach opposition on August 20.

Saturn reappears in the predawn skies of July. It stands near Zeta (ζ) Tauri, one of the horns of Taurus the Bull. On July 2 **Mercury** and Saturn lie 14" apart, and both are visible in the same telescopic field of view. Only visible in bright morning twilight, this is the closest appulse of two planets this year and will require telescope or binoculars to observe. Mercury shines at magnitude –0.5 and Saturn is at magnitude 0.1. On July 25, Saturn lies very close to M1, the Crab Nebula, although catching a view of M1 will be tricky as the sky begins to brighten soon after Saturn reaches a reasonable altitude. Next month's viewing of the Ringed Planet will be much easier.

Always an observing challenge, Pluto (arrow) is barely discernible in this starfield. Paul Roques



Meteors and Moons

Streaking under the light of the moon

Late July brings a few notable meteor showers, but the gibbous moon severely drowns out their light. Three of them emanate from Aquarius: Southern Delta Aquarids, Southern Iota Aquarids, and the Northern Delta Aquarids. The most active, the Southern Delta Aquarids, reaches a peak zenithal hourly rate of up to 20 meteors per hour on July 28. The gibbous moon will restrict viewing to only the most patient observers. As the bright moon wanes, you might also spot a few bright Perseids leading the trail, which are due to peak on August 12.

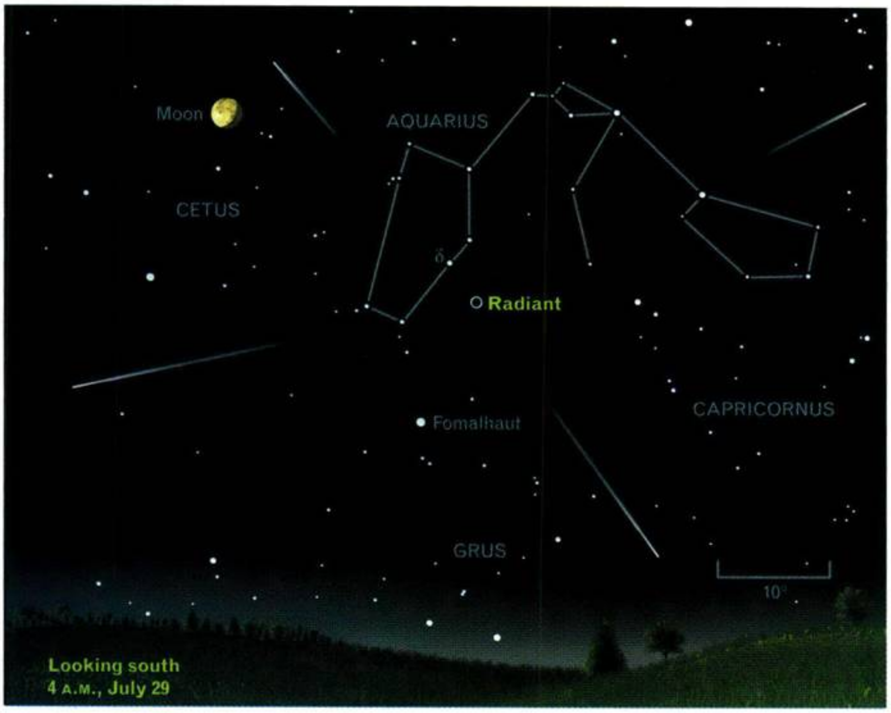
Grin at Grimaldi

Features near the moon's limbs exhibit wide variations in appearance due to a phenomenon called libration. Libration is a gentle rocking back and forth of the moon in both latitude and longitude, caused by the combination of its varying orbital speed and a steady 27.3-day period. The result is that we get to see more than 50 percent of the moon's surface each month. The appearances of features near the limb are most affected by libration.

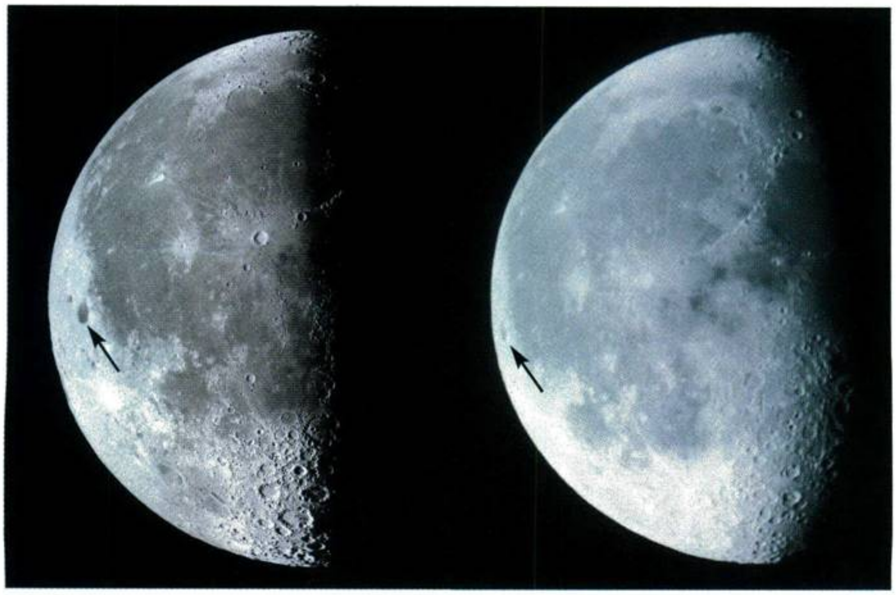
Grimaldi — a large, flooded plain near the western limb of the moon — shows dramatic differences to lunar observers this month due to favorable libration episodes. Notice between June 24 and July 7 how Grimaldi moves close to the limb and then away again. This fascinating sequence repeats beginning July 24 to August 6.

Each night in late June Grimaldi appears closer to the western limb. From July 1 to 7, as the waning moon progresses, Grimaldi begins to move away from the limb as the western side of the moon tilts gently toward us once again.

As the sun rises over Grimaldi, which occurs just before full moon, the massive plain appears dark for a time, while the region around it is in full sunlight. The lava floor of Grimaldi is about 87 miles (140 km) across and its "walls" are rather indistinct in many parts. The western reaches are quite prominent with some rough terrain spreading from the floor up to the wall. To the south, a large crater sits over a very indistinct wall, and a line of smaller craterlets dot the area.



Looking south
4 A.M., July 29



Left: Lunar libration allows one to see more of the terrain edging the moon's limbs. The Grimaldi region (arrow) is easier to see on the left than on the right. Gerard Thérin and Martin Andersen

Below: A Perseid meteor streak may whet your whistle for next month's shower. Graham Sinagola

Eleonora sails the Rift

It's not often we get a chance to watch a high-numbered rock like 354 Eleonora with a small scope. The bigger the number, the fainter an asteroid, because asteroids are numbered in order of discovery. But those with moderately elliptical orbits can brighten considerably when they are closer to Earth than usual.

An 8-inch scope will have no problem revealing the starlike dot of Eleonora from city suburbs — as long as you're on the south side, not peering through a veil of light pollution. At magnitude 10.7, Eleonora will lie low in the sky in Scutum, then cross over into Ophiuchus as the nights pass. This region of sky is called the Great Rift, where spiral arm dust and dark gas block light from our galaxy's central bulge.

Start at Eta (η) Serpentis, the lone star in the Great Rift to the right of the Scutum starcloud, and drop south to get to the field. By the end of the month, it closes in on Tau (τ) Ophiuchi. Use the opportunity to check out the dim globular cluster NGC 6539. If you're under country skies, try for IC 1276, a granular globular, glowing at magnitude 10.3.

Comet Ikeya-Zhang fades near M5

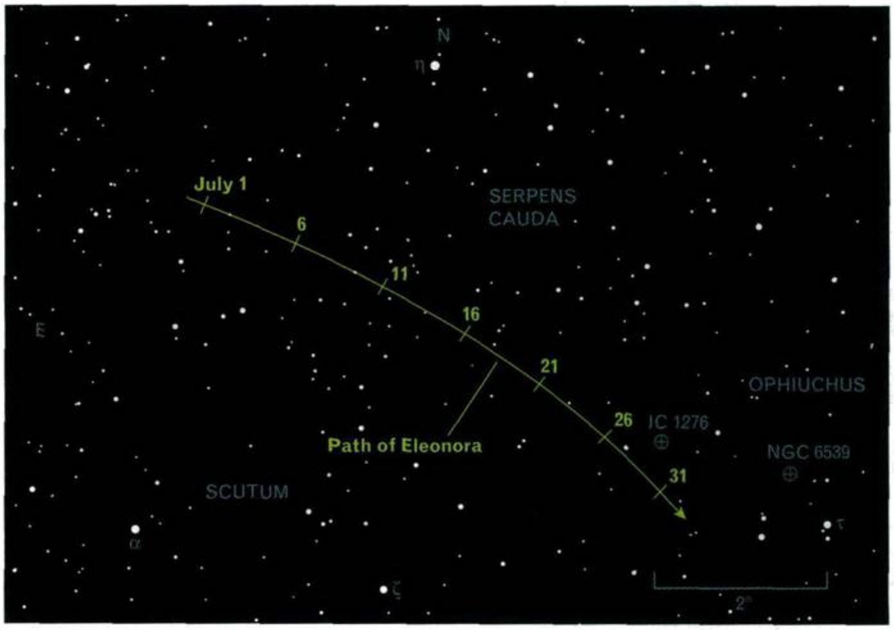
With near perfect timing, a bright comet vaulted into the evening sky for the planet line-up and added a special treat for Astronomy Day observing. If the codiscoverer's name, Ikeya, sounds familiar, it should. He also found the amazing Ikeya-Seki sungrazer in 1965, which was even visible in daylight.

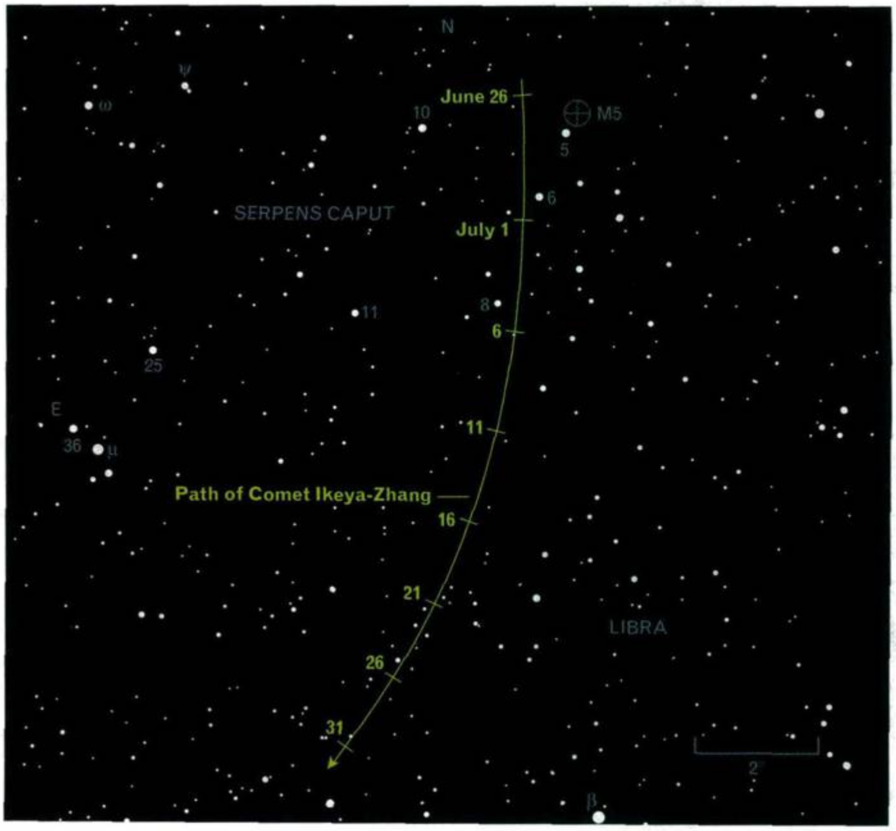
Now on its outbound leg, Ikeya-Zhang is dimming quickly, but still visible in the evening sky in Serpens Caput. Since it is likely to glow at 11th magnitude, you'll probably need at least an 8-inch scope to locate the diffuse snowball. Before July begins, on June 27, the comet passes a little less than 1°, or two apparent lunar-diameters, from the bright globular cluster M5.

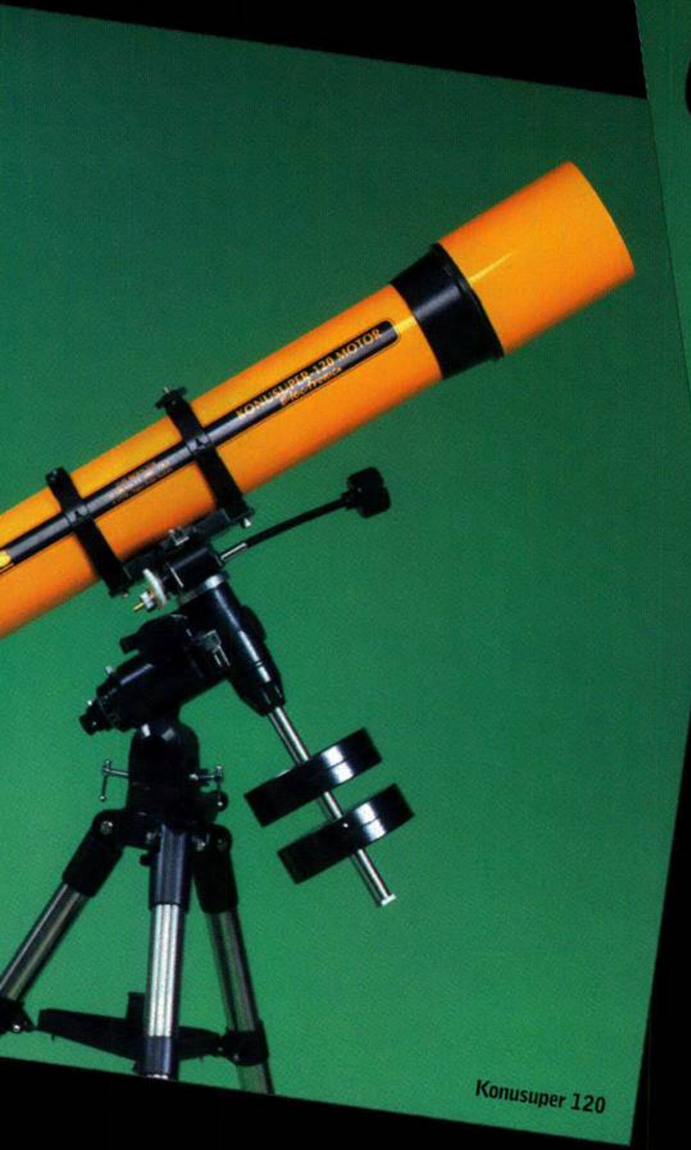
Use the chart to zoom in on its position. You may not be able to see it at low power, so move up to 100x or so. Be patient as you slowly scan around its predicted position. Actually, a moving scope sometimes makes fainter objects appear a little easier to keen observers.

This comet is a prime example of the value of the Internet. For more information see websites like NASA's http://encke.jpl.nasa.gov/ for updates on comet activity.

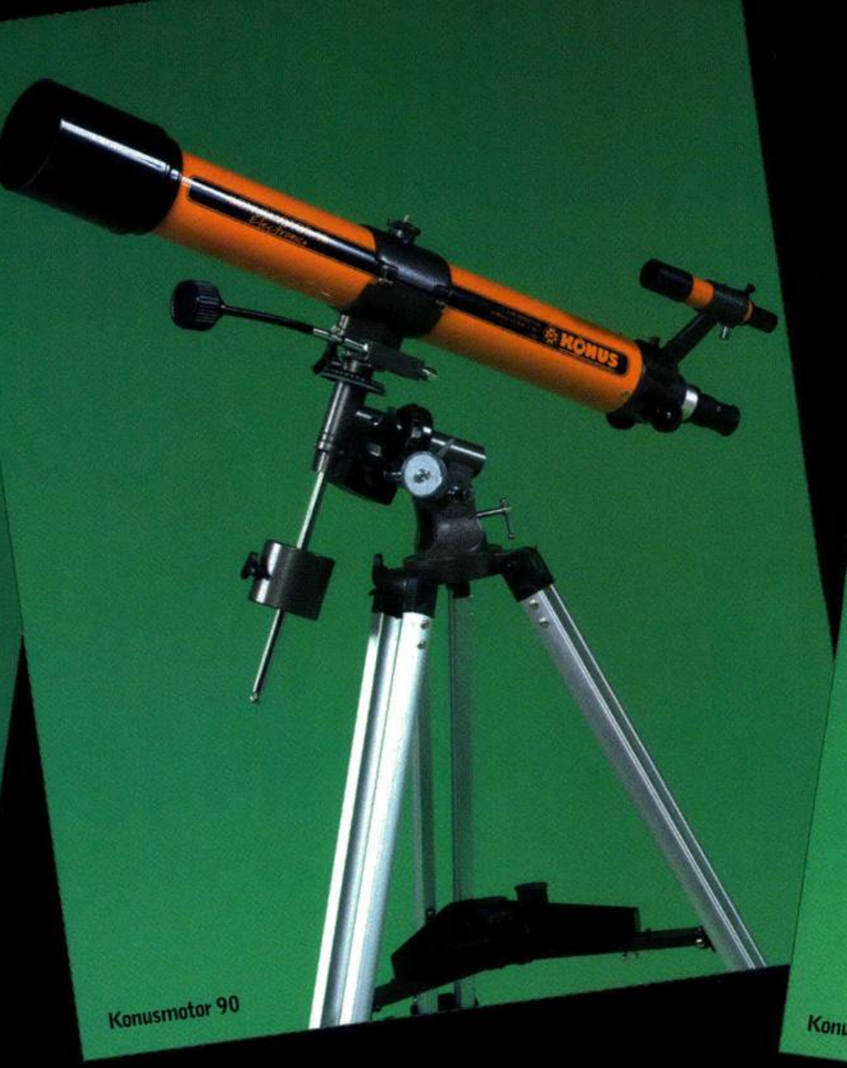
Martin Ratcliffe is President of the International Planetarium Society and observes from Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.







Konusuper 120



Konusmotor 90

Konusm

Get the Scoop on

Konus offers four classic telescope packages, with an Italian twist.

by John Shibley

If you live in North America, chances are you haven't heard of Konus. However, if you read European astronomy magazines, you've most likely come across Konus advertisements or reviews. Based in Italy, Konus makes telescopes, spotting scopes,

ator 500

KONUS
KONUSKY-150

Konusky 150

All photos *Astronomy*: William Zuback

Italian Scopes

binoculars, and microscopes mainly for the European market. All told, it offers nine different telescope packages, ranging in size from a 2.3-inch altazimuth refractor to a 6-inch equatorial, motor-driven refractor. But only recently has Konus been looking to the North American market. Hoping to make a bigger impact in this market, Konus is introducing four scopes for beginning and intermediate observers: Konusuper 120, Konusky 150, Konusmotor 500, and Konusmotor 90.

Left to right: In the Konusmotor 500, beginning observers get a 4.5-inch scope with nice optics; the Konusmotor 90 refractor, a 3.6-inch refractor, has an equatorial mount and clock drive; the Konusuper 120 package comes with a 2-inch focuser and 6x30 finder; the 6-inch Konusky 150 offers a 2-inch focuser and 9x50 finderscope.

Two Packages for Beginners

These days, popular beginner scopes are usually categorized into two distinct categories: computer-driven Go-to scopes and oversized light-bucket Dobsonians. Two offerings from Konus, the Konusmotor 90 refractor and Konusmotor 500 reflector, take a more traditional approach to first telescopes.

The Konusmotor 500 (4.5-inch aperture; "500" refers to its focal length) is a small-aperture instrument that is quite affordable for first-time telescope buyers. It comes bundled with a German equatorial mount on a telescoping tripod, a 5x24 finder scope, a moon filter, and two 1.25-inch barrel-diameter eyepieces: an F6mm (that yields a magnifcation of 83x) and H20mm (25x).

This little reflector excelled at providing stunning wide-field views of the Milky Way. Although the supplied H20mm eyepiece yielded a nice low power (25x) for sweeping the sky, I found that its rather rudimentary optical design offered an overly narrow field of view and poor eye relief. Swapping this eyepiece for a wider-angle, 25mm Plössl (available from Konus) fully unleashed this reflector's potential as a rich-field telescope.

To verify the main mirror's performance, I star-tested it on the defocused light of Vega. For this, I used a 6mm eyepiece included with the Konusmotor 500, coupled with a Tele View 2.5x Barlow that did not come with the package. At this power, Vega came to a sharp focus — as sharp as I would expect from a telescope with a secondary mirror obstructing its incoming light path.

Sometimes a reflector's optical alignment requires some minor tweaking to maintain peak performance. The Konusmotor 500's primary and secondary mirror cells offered perhaps the best collimation controls in this category of telescopes. The main mirror's adjustment knobs are oversized and easily found and turned in the dark. Three flat-head screws tighten into place on the back of the cell once you've made the desired adjustments. The secondary mirror mount has three hex-head adjustment bolts that are raised enough to be turned using your thumb and forefinger.

The Konusmotor 90 is a 90mm (3.6-inch) f/10.1 refractor that comes packaged with an equatorial mount and tripod, a 6x30 finder scope, a moon filter, and two 1.25-inch Plössl eyepieces: a 10mm (which provides a magnification of 91x) and a 17mm (53x). Their Plössls (an eyepiece type seldom included with beginner telescope packages) sport a relaxed field of view.

As you would probably expect, this refractor's unobstructed optics excelled at providing generous views of the moon and planets. Of the two beginner Konus packages, the 90mm performed beautifully on splitting colorful and close double stars. Magnitude-4.7 Xi Böotis, a nice double, revealed its magnitude-7 secondary shining some 7" to the northwest of the primary star. The colors in this duo were breathtaking; the 90 offered up the best view I'd ever seen in a scope of this class.

What struck me the most about these views were the very clean and distinct Airy disks each star showed at sharp focus. The wave nature of light makes high-power images of stars appear not as focused points of light, but as disks surrounded by three or four progressively faint, concentric rings. If a refractor's lens is not mounted properly or is ground incorrectly, these rings will look distorted. The Konusmotor 90's Airy disks and rings were essentially flawless.

The Konusmotor 500 and 90 are packed with nearly identical equatorial mount head and telescoping tripod combos. Many beginner scopes come with undersized right ascension (R.A.) and declination bearing surfaces. This often means that images seen through the eyepiece take several seconds to settle after repositioning or focusing. The bearing surfaces in the Konus mounts were beefier than the norm; the time it took vibrations to dampen out was impressively and exceptionally short.

The Konusmotor 500 features Konus's slightly smaller equatorial head. The mount that shipped with the Konusmotor 90 refractor has slightly wider (about a quarter-inch) right ascension and declination bearing surfaces. Both mounts come with the identical clock-drive motor that moves the right ascension axis with the sky. Otherwise, you can manually track with the sky using the slow-motion knobs.

The clock-drive motor is no-frills and self-contained, powered by a single 6-volt battery. I had to swap out a slow-motion control knob fitting on the R.A. axis for the motor/control box. The box face includes a power switch, a power-on LED, a speed-adjustment knob, and a toggle switch that lets Southern Hemisphere users reverse the motor's direction of travel.

For the Intermediate Observer

Konus markets two refractor packages for intermediate observers, or for beginners who want to gain a substantial toehold into intermediate-sized refractor astronomy.

The Konusuper 120 features a 4.7-inch f/8.3 achromatic refractor shipped with what Konus calls their "Super Polar

Left to right: The Konusmotor 500 reflector's drive control mechanism is a snap to use; the business end of the Konus refractors allow for easy eyepiece changes; the equatorial heads used by Konus are substantial enough to provide steady support; the Konusky 150 refractor features large plate counterweights and the trademark telescoping tripod.

System" mount. It sports 2.25-inch diameter right ascension and declination bearings and drive motors that attach to each axis for dual-axis control. These drive motors install with a screwdriver. Both motors feed into a control box that can motor-slew the scope in one or both axes simultaneously at 2, 4, and 8 times the normal right-ascension tracking rate. This translates into a slew rate of, respectively, 1°, 1.5°, and 2° per minute.

The Konusuper 120 package also includes a 2-inch focuser with a 1.25-inch adapter, a 6x30 finderscope, a star diagonal, a moon filter, and two Plössl eyepieces: a 17mm (58x) and 10mm (100x). The tripod's telescoping-tube design proved the most stable of any of the Konus tripods I evaluated. (The other packages featured extendable-leg tripods that I found weren't as solid.)

The Konusksy 150 package offers the largest-aperture refractor in the Konus line, a 6-inch f/8. Tube rings on a dovetail plate attach the telescope to its mount, a rugged "Super Polar Evolution" that sports 2.5-inch-wide bearing surfaces on its right ascension and declination axes. This mount looks very similar to Super Polaris and Great Polaris mounts marketed by the Vixen and Celestron. The package also includes a 9x50 finder scope, slow-motion control knobs, a 2-inch focuser with a 1.25-inch adapter, a 1.25-inch star diagonal, a moon filter, and two Plössl eyepieces: a 25mm (48x) and 10mm (120x).

Curiously, the Konusky 150's mount doesn't ship with a clock drive or, as its smaller sibling the Konusuper 120 has, dual axis drives. Provisions are made for upgrading to those features, though.

The mounts for both scopes incorporate a polar alignment scope, a useful item for precisely aligning the polar axis with the north celestial pole. The alignment scope slips right inside the polar axis, so, in essence, you sight right up through the axis you want to align toward the sky.

The polar scope has crosshairs that pinpoint the celestial pole's location, and an offset set circle where Polaris is supposed to go, in a direction toward the star Beta Ursae Minoris. For alignment during this step, a fine adjustment knob on the mount pivots the equatorial head left and right. A five-minute procedure using these features aligns the mount dead on the pole. For astrophotographers, this eliminates a major source of tracking error.

Konus also offers polar scope reticules for observers who live in the Southern Hemisphere, where there is no bright star near its celestial pole.

Both the 120 and 150's refractor tube assemblies offered very good optics. I placed the bright gibbous moon just out of each telescope's field of view, fitted with a Konus 17mm Plössl. Placing an almost fully-lit moon is one of the best ways to gauge how well a telescope's tube and optics handle glare through interior baffles and a low-reflection, light-absorbing interior.

Both telescopes also exhibited slight color error, a common problem in achromatic optics where all the colors in the visible light spectrum, especially on the violet end, don't come to the same focus. While the color error was noticeable, it didn't detract from views of tight double stars and brighter showcase planets like Jupiter and Saturn.

In fact, the 6-inch's optics worked spectacularly well in showing brownish jovian cloud belts adorned with black, hook-like festoons. Steady views, working at magnifications up to 300 power, allowed both refractors to present the Cassini Division in Saturn's rings more plainly than I've seen before with scopes of this aperture.

Both scopes had a neat feature built into their front lens caps — what's essentially a second, smaller interior cap that serves as stop-down aperture. Viewing through a stopped-down aperture conveys two additional benefits. By only allowing light through the objective's center portion, it drastically reduces color errors. Stopping-down also seems to somewhat sharpen up image clarity. The trade off, of course, is that you effectively reduce telescopic aperture, in this case from 6 and 4.7 inches to, respectively, 4.5 and 2.4 inches.

To Konus, or Not To Konus

So what constitutes an ideal scope for a beginning or intermediate backyard observer? Herd mentality might drive you toward an undersized, computer-controlled compound scope. But one should embrace exploration with more than a modicum of simplicity.

The Konusmotor 500 and 90 don't have the bells, and don't sport the brawn. What they do offer are classical starter scopes built with quality and no frills. The sky as seen through a telescope, pure and simple.

As for the Konusuper 120 and Konusky 150, they are ideal investments if you're ready for the sights that larger unobstructed optics can provide of the moon and planets. For the quality and affordability, these refractor packages are tough to beat. ■

John Shibley is an Astronomy *contributing editor and active telescope tester living in Michigan's Upper Peninsula.*

Close Encounters with Satellites

Whether by accident or by design, viewing satellites puts a whole new spin on skywatching.

by James E. Oberg

June 14, 1980, an hour after sunset. It was a beautiful Saturday night in Argentina, and many people were out enjoying the clear skies and warm air. Until suddenly, something out of the ordinary appeared.

Pilots and control tower personnel at Newbery Airport in Buenos Aires reported a glowing object hovering in the sky near the airport. Around the same time, a "circular flying mass" chased a family driving home from a visit to Cordoba. They pulled their car off the road and stopped, and reported that the object descended toward them "with vertical and circular movements, leaving a bright trail of whitish smoke," and then disappeared before their eyes.

Visual descriptions were mostly consistent. "It looked like a full moon but fainter," one pilot said, "and it was surrounded by a sort of halo." At Newbery Field a controller called it "a sort of sphere that was dim in the middle and brighter around the edges."

A Vandenberg rocket launch on October 2, 1999. Bill and Sally Fletcher

Jari Annelin

Frankie Lucena

James W. Young

August 12, 1986, 10 P.M. Hundreds of thousands of people were outside in the eastern half of the United States, looking for Perseid meteors. Many of them had their astronomical instruments and cameras at the ready.

Suddenly a bright, fuzzy spiral, wider than the moon, appeared in the eastern sky, moving from right to left. Sightings occurred from Georgia (Florida was socked in with clouds) to Texas, from Oklahoma City to Quebec, Canada, and all points in between. Descriptions of the object and its motion varied, but a general picture soon emerged. It was called a pinpoint, a moving spiral, a glowing cloud, and "a big ball of fire." The vice president of the Syracuse Astronomical Society in New York said it resembled a "reflection of the moon off a cloud, but it was very iridescent, very vivid." Wayne Madea, an amateur astronomer in northern Maine, saw a bright starlike object emit a luminous, rapidly expanding donut-shaped cloud; through a telescope he saw "a pinpoint of light, like a satellite, traveling with the cloud." In Massachusetts, an amateur astronomer watched the plume perform two full turns in four minutes, painting the spinning spiral as he watched.

Both events, along with countless other similar sightings, left observers stunned and baffled. What had they seen? UFOs?

But some suspected that it was something far less exotic, though still interesting. Richard C. Eaton, a retired engineer in Fayetteville, New York, told a local newspaper he guessed he had seen a cloud that was part of a Japanese rocket launch.

As it turned out, he was right.

Despite the fluid-like or cloud-like texture of the apparitions, the witnesses hadn't really been seeing anything liquid or gaseous. They had been watching "snowstorms" in space, resulting from artificial satellites.

In Argentina, the mysterious object turned out to be the sunlit propellant cloud dumped from the fourth stage of the Soviet rocket that had just carried Kosmos-1188 into orbit. It was moving from southwest to northeast at an altitude of over 500 miles (900 km), lit by the sun to the west. This satellite was in a "Molniya" orbit, ranging between nearly 400 and 25,000 miles (600 and 40,000 km) of Earth to serve as a communications relay or, as in this case, a missile launch warning system.

In the United States and Canada, observers had witnessed a spray of surplus fuel from the used-up third stage of the Japanese rocket. Their altitude was almost a thousand miles (1,500 km), high enough for it to have been sunlit even though the ground below had been dark for more than an hour.

These kinds of events are happening more and more often, and even better, satellites can sometimes be predicted and photographed. Watching artificial satellites, even if they are just dots of light crossing the sky, can be thrilling. Sometimes they flare brightly when solar wings catch the sun. Sometimes they flash periodically as they tumble. Sometimes they fly in formation with other satellites. And just knowing what they are, or even who's on board, is usually enough to make it worthwhile. But when the event is unexpected, satellites can leave many people stunned and even frightened.

Cosmic "dumps"

"Propellant dumps" became a standard operation, as rocket engineers realized that leftover fuel inside spent rocket stages could eventually explode, showering nearby space with hundreds of fragments and thus contributing to the mounting "space garbage" problem. So valves on the propellant tanks come open a few minutes after the last scheduled rocket engine firing, and the liquid sprays into space. As it sprays, it gently pushes back on the rocket, sometimes inducing a slow spin.

The liquid droplets shoot out at speeds of more than 300 feet (one hundred meters) per second. In the vacuum of space, the outer layers instantly evaporate, cooling the remaining material until it freezes. It is these little pieces of ice — some of them crystallized like snowflakes, some of them just tiny fragments — lit by the over-the-horizon sun that people on the ground see. If the rocket is slowly tumbling, as it was in August 1986, the stream paints a spiral in the sky. Sometimes the cloud spreads out in all directions, forming a sphere.

The original liquids often were rocket propellants, but sometimes other fluids were involved. During the first manned Mercury orbital flight in 1962, John Glenn described a cloud of "fireflies" around his capsule, which turned out to be snowflakes from water that was emitted from the craft's cooling system. On Apollo missions, the astronauts dumped urine overboard and marveled at the sight of sunlit yellowish snowflakes (which one spaceman dubbed "the Constellation Urion"). Wastewater from space shuttle missions (and now from the International Space Station) is routinely dumped, and ground observers are often startled to see the shuttle moving across the twilight sky with a "comet tail."

Scott Young, on the staff of the Manitoba Planetarium in Winnipeg, witnessed a water dump in 1999, while helping a class of astronomy students in an observatory. A scheduled pass of the docked shuttle and station (with a Canadian astronaut aboard) was expected. "About two minutes before the predicted time, a round hazy spot rose in about the right spot and started ascending, trailing a hazy contrail behind it," explains Young. "As the spot rose higher, the trail got longer and longer, twenty degrees at maximum. It reminded me of a naked-eye view of Comet Hyakutake from light-polluted skies."

Young admits the sight of the expanding cloud made him anxious, until he could see the docked vehicles rise. But the students were puzzled that the "tail" was preceding the presumed

Chris Dorreman

Steinar Midtskogen

Iridium flares, glints of sunlight from iridium satellites, provide excellent photo opportunities for observers. From left to right: Iridium 67 taken from Alberta, Canada, December 1998; Iridium flare taken from Cabo Rojo, Puerto Rico, January 2000; Iridium 52 taken from the White Mountains, California, August 1999; Iridium 10, taken from Belgium, April 1998; Iridium 19, taken from Oslo, Norway, August 1998.

source of the dump, the shuttle itself. The swarm of ice particles that results when water is dumped from a shuttle follows a strange path through space, and this has confused many ground and space observers for years. To prevent the expelled water from recontacting the shuttle, Mission Control usually instructs the crew to direct the stream downward, or even backward against the shuttle's motion through space. Objects moving backward from the shuttle are then going too slowly to maintain their original altitude, so they slip into lower orbits. By momentum conservation laws, they pick up speed along those new paths and quickly pull ahead of the shuttle, staying slightly below it. The stream often appears to move "out the back" of the shuttle, then curves downward and turns back forward.

Even small particles that separate from a satellite in any direction will follow this path. Weak drag from the ultra-thin air at orbital altitudes affects smaller, less dense particles more strongly, and this reduces their forward speed and drops them naturally into lower, faster orbits. John Glenn noticed this baffling motion when he reported that the "fireflies" he spotted around his Mercury capsule during one sunset were preceding him toward the horizon. They were following "orbital mechanics," although it took a while for space experts to realize it.

"Space dumps" and the resulting visual phenomena have been going on since the dawn of the space age, but at first they were accidental, and nobody thought they would be visible from the ground. As a result, observations of the phenomenon were rarely written down, and only then in UFO files. But now that these kinds of cloud-like apparitions have been recognized, the logbooks of many observatories and naked-eye astronomers can reveal a wealth of explainable sightings.

"UFOs" Revealed

One typical case came from the Soviet Union. On November 30, 1964, at 6 P.M. local time (an hour after sunset), at the Shamakhinskiy Observatory in the Caucasus Mountains of Azerbaijan, astronomers M. Gadshiyev and K. Gusev saw an object moving from west to north. The head of this object was twice the diameter of the moon. It looked like a ring with a sharp internal edge and a diffuse outer edge. In the center was a starlike object, which appeared as a point even through a telescope. It left a tail that was visible for more than 15 minutes. While the sighting baffled astronomers then, we now know that it correlates with the launching of the Soviet Zond-2 interplanetary probe. It had blasted off from the Baykonur spaceport an hour earlier, circled Earth once, and fired its last stage engine to break free of Earth's gravity. The apparition seen in Azerbaijan was the post-burn surplus fuel dump.

Other similar instances have never been properly explained. The Japanese H-1 booster that had sparked the eastern U.S. sightings in August 1986 repeated its performance on another launch a year later. As it was completing its first orbit of Earth, the last stage soared through the post-sunset skies of central China and Taiwan. Its propellant was still spraying outward.

Witnesses reported spotting a UFO between about 7:30 and 8:30 P.M. local time. Ground observers reported a glowing object that looked like an oval plate or a comet, with a tail resembling an umbrella. It was orangish in color, and spun clockwise as it flew eastward. News services around the world picked up the story and briefly splashed it across radio, television, and newspapers, all without any mention of the true explanation of the sighting.

This view of the International Space Station arcing across the sky was captured from Ohio in early July 2001. William K. Guegold

If the location of a given satellite, such as the ISS, is known in advance, observers can capture unique photos . William K. Guegold

Catching a Glimpse

More than 2,500 satellites currently orbit the Earth. While many have fulfilled their purpose and are now out of commission, the rest serve a variety of functions, ranging from weather predicting to television and voice communications to military purposes.

So how can you plan ahead to view a satellite, instead of relying on blind luck? By simply logging on to the Internet, you can find out when particular satellites will pass over any given location on Earth. Check out Heavens Above (www.heavens-above.com) to discover when you'll have the opportunity to spot one from your location. On this website, you can access brightness and path predictions for particular targets, such as the International Space Station. Or choose from a complete listing of satellites based on their estimated brightnesses. The website even devotes an entire section to spotting iridium flares, glints of sunlight from satellites in the iridium telephone network.

NASA also offers several helpful websites for satellite observers, such as J-Pass (liftoff.msfc.nasa.gov) where you can view their online satellite predictor. Or check out NASA's Human Spaceflight website (spaceflight.nasa.gov) to find out when the International Space Station will arc across your sky.

No matter where you live, the Internet is sure to provide the information you need to catch a glimpse of one of Earth's manmade satellites.

— Elesa Janke

Planned Events

These observations had all been accidental, because the space events were unplanned, or followed schedules that weren't available to the general public. But over the years, both spaceflight operations and the skills and ambitions of amateur ground observers improved. And as some satellite launchings became routine, and rocket burns occurred at higher altitudes, the opportunity arose for advance alerts on widely observable propellant dumps. Observers, forewarned by published schedules and armed with home-computer astronomical software, could look toward the portion of the sky where the dump would occur. It wasn't just luck any more.

Rocket launches often leave beautiful vapor trails, such as the one created by a Vandenberg rocket launch in October 1999. Bill and Sally Fletcher

In the summer of 1999, observers the world over geared up to watch four expected launchings of groups of Globalstar communications satellites aboard Delta rockets. Each would blast off from Cape Canaveral, but the upper stage would be fired much higher in the sky, at an altitude of about 900 miles (1,400 km). After deploying the satellites, the rocket was to dump the rest of its propellant through a depletion burn. It was this cloud that observers were eager to watch, and many interesting reports followed the event.

Ted Molczan, an experienced Canadian observer, described what he saw during one launch on July 10. "On time at 10:41:27 UT the depletion burn started. This one was awesome. Soon after the burn started, I made a note that it was turning. At 10:41:56 UT it went between two target stars and I observed the plume easily with the naked eye."

Jake Rees observed another satellite deployment on August 17, 1999, through binoculars near his home in Burbank, California. The predicted view was to the northeast, at an elevation angle of only 11°, but he still saw it. "It certainly would not have been noticed except by someone looking directly at that spot with binoculars," he added. "I had to walk to a street bordering on an athletic field near my house to get a view that close to the horizon. Two guys pulled up in a pickup truck in front of their house just as the cloud appeared. I would have told them what I was looking at but they didn't ask. I guess they just weren't into observing depletion burns."

Daniel Deak in St. Bonaventure, Québec, also watched the depletion burn and dump through binoculars. "What I saw was so impressive! It looked like a horn of plenty roughly parallel to the horizon with its right tip curved to reach the rocket, which was at magnitude four or five." Deak was so intrigued that he then sketched the apparition and posted the image on his Internet home page.

These happy results portend more occasions when predictions of satellite apparitions can be made and disseminated in time for amateur observers to spot them. But most such events will continue to be unexpected, and for most fortuitous observers, unexplainable. Whether by design or by luck, observers who are treated to such spectacles will experience yet another awesome reward for raising their eyes to the skies. ■

James E. Oberg observes satellites from his home in Dickinson, Texas.

NEXT month in Astronomy

STScI

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Hercules and Serpens Cauda

Galaxy-filled constellations give way to the Strong Man for a variety show of clusters and nebulae.

by Tom Polakis

Early summer months find many observers awaiting the rise of the Milky Way's band. As the galaxy-filled constellations of spring depart, the star density slowly rises with the summer constellations. This effect is most pronounced in the constellation Hercules the Strong Man, which rises a couple hours before the Summer Triangle. The proximity of Hercules to our galaxy's plane results in a constellation rich in clusters and nebulae. To the south is the eastern portion of the constellation Serpens the Serpent. Serpens Cauda (Serpent's Body) is a patchwork of rich starfields and dark nebulae associated with the center of the Milky Way.

At the center of Hercules is its most familiar asterism, the Keystone, a quartet of stars in a well-defined pattern. While the pattern seems to stand out as an associated group, the four stars are quite different. At the southwest corner, Zeta (ζ) Herculis is a modest star only seven times as luminous as the sun and 35 light-years away. At the other corner of the Keystone is Pi (π), more than 500 light-years away and as bright as 500 suns. For viewers in the Northern Hemisphere, the pattern of Hercules is inverted. The legs are to the north and the arms are south of the body. From a dark site, look for a long string of faint stars that spans 25° between Delta (δ) Herculis and the south end of the parallelogram of Lyra.

To the south, Serpens Cauda lies along the Milky Way's plane, but its objects are quite obscured by the dark nebulae of the Great Rift. Only the south edge of the constellation reveals rich starfields. The east end of the serpent is seen as a wide chain of four bright stars, the brightest of which is 3rd-magnitude Eta (η) Serpentis, a blue-white star 60 light-years away.

Any tour of Hercules begins with M13 (NGC 6205), the **Hercules Cluster**. As one of the brightest nonstellar objects, it shows up with unaided vision as a fuzzy "star" two-thirds of the way from Zeta (ζ) to Eta (η) Herculis in the Keystone. Containing stars as bright as 12th magnitude, M13 resolves fully in apertures as small as 3 inches. An 8-inch telescope shows hundreds of stars with streamers emanating from the edge. The cluster doesn't seem any more difficult to resolve at the core. Many observers note the presence of a small Y-shaped region of three dark lanes near the center dubbed "the propeller." These lanes are best seen at magnifications in excess of 200x. In medium apertures, the full extent of the cluster nearly fills a high-power field. The core is distractingly bright, and even around the edge, resolved stars are seen against a background glow of thousands of unseen stars. M13 is about 25,000 light-years away, and shines with a brightness of more than 200,000 suns.

Less than a half-degree northeast of M13 is the spiral galaxy **NGC 6207**, which forms a pretty picture in the same field with the magnificent globular. NGC 6207 is 1,600 times farther away than M13, producing an excellent study in depth through the eyepiece. A cluster as bright as M13 in this distant galaxy would appear as a 22nd magnitude dot. NGC 6207 is most commonly observed at magnifications of 100x and below, and when the two objects sit within the same field. With telescopes of 12 inches or more aperture, though, you can pull some detail out of the spiral. The galaxy readily reveals a bright core and a

Artwork from *The Glorious Constellations*, © 1991; Harry N. Abrams, Inc.

Klaus Brasch

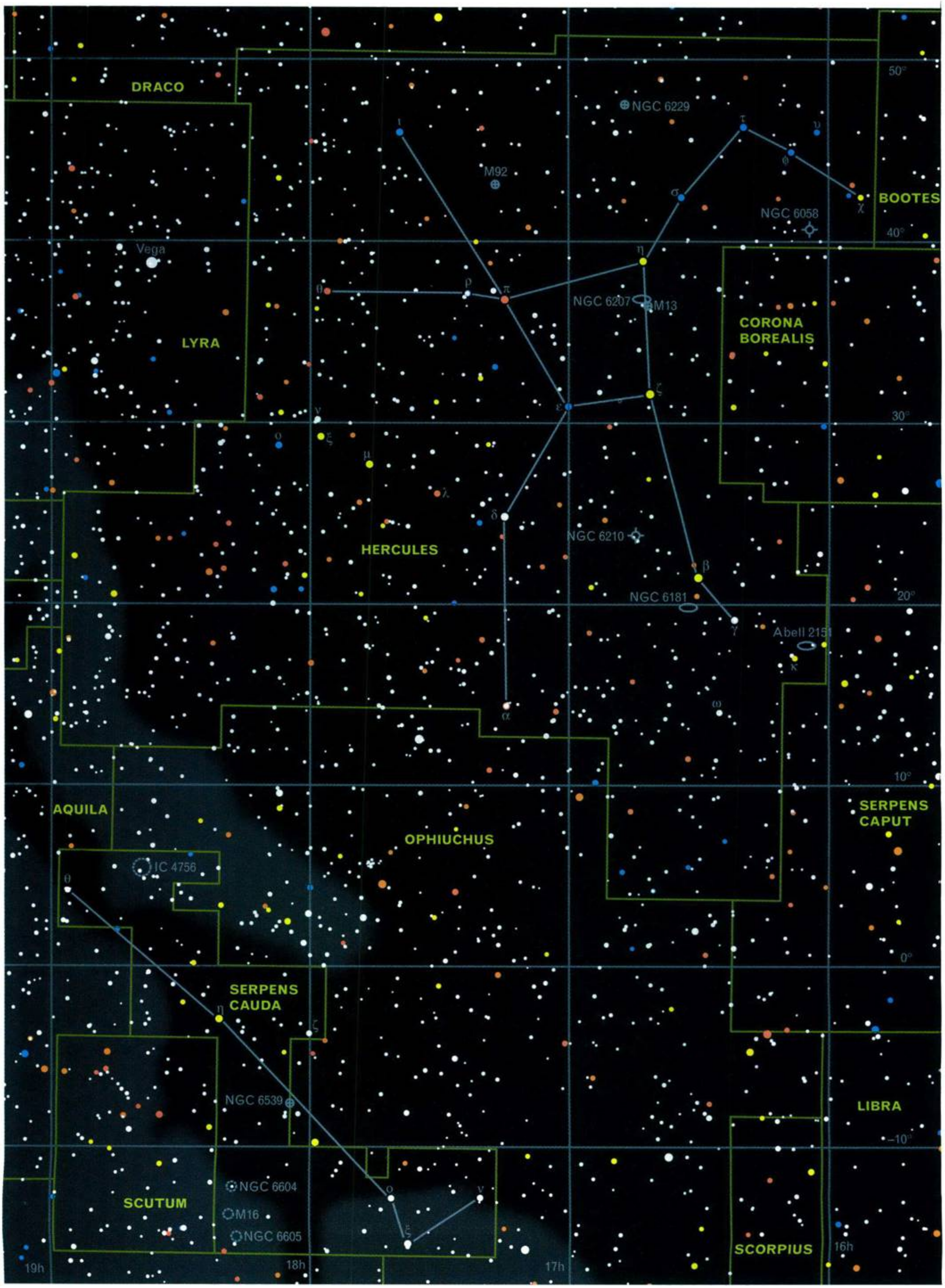
surrounding 2' by 1' haze. Look for faint enhancements at the north and south edges — the ends of the spiral arms.

If observing NGC 6207 becomes passé, take on a much greater challenge with tiny **IC 4617**, fortuitously located nearly halfway from the core of M13 to NGC 6207. At a very dark site, it's visible in a 13-inch scope, but only as a barely nonstellar object. This galaxy requires a magnification of at least 200x to spot.

Begin at 4th-magnitude Phi (ϕ) Herculis and pan over 4° south to locate the small planetary nebula **NGC 6058**. The bright disk is 20" in diameter. A 10-inch telescope at 300x shows a uniform object with a sharp edge. In good seeing conditions, the 14th-magnitude central star peeks through. Large telescopes reveal brighter markings on the disk to the north and south of the central star.

The remote globular cluster **NGC 6229** shows up in the northern reaches of the constellation. This outer-halo cluster is 90,000 light-years from both the galactic center and the sun. This great distance manifests itself in the faintness of NGC 6229's stars; the brightest members glow at only magnitude 15.5. An 8-inch telescope at 200x shows a clumpy haze 2' across that forms a triangle with two 8th-magnitude stars to the west. Doubling the aperture results in a surprisingly well-resolved cluster nearly 4' across. At least fifty faint stars will begin to pop into life at higher magnifications. The bright, concentrated core is roughly 2' across.

Now moving into a cluster that is only one-third as distant as NGC 6229, we come to **M92** (NGC 6341). Backyard observers can locate this globular by slewing 6° north of the Keystone star Pi Herculis. It very nearly keeps up with M13, but is often neglected because it's more difficult to spot. With stars nearly as bright as those in M13, M92 is easily resolved in small scopes. A highly concentrated core is about 3' across, and the outer halo grows with aperture, reaching nearly 12' in diameter through larger scopes. Back off to a low magnification and glimpse the north-south elongation to the outer halo. M92 is currently 30,000 light-years from the galactic center, but its oval orbit will bring it as close as 4,000 light-years to the center.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NGC 6604
SCUTUM
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19h
18h
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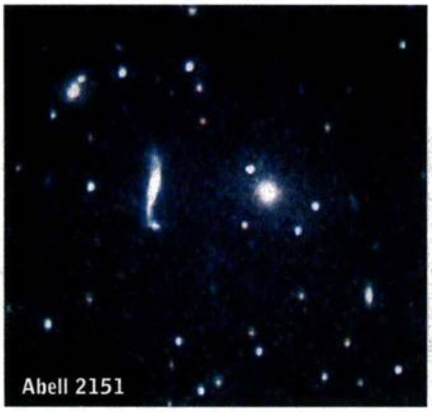
16h

Use the 4th-magnitude star Gamma (γ) Herculis as a stepping stone to a cluster of galaxies that is worth viewing if only for its great distance. The nearly 150 galaxies of **Abell 2151** lie more than 500 million light-years away and are packed into a diameter of less than 2° across. The brightest member of the Hercules Galaxy Cluster is the elliptical galaxy NGC 6047, which glows at magnitude 13.5. A high-magnification pan around this centrally located galaxy in a telescope of 12 inches or more aperture will turn up a couple dozen cluster members. The remote galaxies typically appear less than one-half arcminute across, barely distinguishable from faint foreground stars. In a large Newtonian scope at a dark mountain site, several fields appear filled with the clumpy structure of closely spaced galaxies. Abell 2151 is a member of the Hercules Supercluster, which includes Abell 2152 and Abell 2147 to the south. The entire supercluster is composed of more than 400 galaxies.

NGC 6181 forms a triangle with Beta (β) and Gamma Herculis. The disk of this spiral galaxy is inclined 30° to our line of sight. At a distance of some 120 million light-years, details are fleeting. A 10-inch telescope reveals an oval halo 2' long and oriented north-south, which contains a broadly concentrated core and a faint stellar nucleus. Scopes of 16 inches of aperture or more are required to glimpse the thin spiral arms that appear as faint bands east and west of the core.



Jack Newton

Jim Egger

Closer to home, the small blue disk of the planetary nebula **NGC 6210** is an easy target in a small scope. In an 8-inch, the uniformly bright disk is 25" by 15", and has a sharp edge. A 12-inch easily shows the central star. This is one of the more colorful planetaries — best seen using direct vision at low magnification. NGC 6210 has a faint halo some 65" across, but represents a significant challenge in amateur instruments. The planetary nebula is 5,000 light-years away.

We turn now to two naked-eye double stars found in the pattern of the constellation Hercules. Third-magnitude **Delta (δ) Herculis** blazes through the eyepiece of any telescope. Look closely using medium magnification, and a white 8th-magnitude companion appears to the southwest. About 10° south is **Alpha (α) Herculis,** which is also an easy split in a small scope. Use high magnification to see the bluish secondary star just 5" east of the orange primary.

It's a long pan to the south into Serpens Cauda, where we find the open cluster **M16** (NGC 6611) and the associated **Eagle Nebula.** While the Eagle Nebula is catalogued as IC 4703, it is

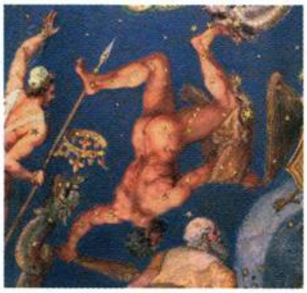
Deep-Sky Objects in Hercules and Serpens Cauda

Object	R. A. (2000.0)	Dec.	Mag.	Size/Sep.	Type	Notes
NGC 6058	16h04.4m	40°41'	12.9	23"	PN	
Abell 2151	16h05.2m	17°45'	—	68'	Gals	Hercules Cluster
NGC 6181	16h32.3m	19°50'	11.9	2.3' by 0.9'	Gal	SAB(rs)c
M13 (NGC 6205)	16h41.7m	36°28'	5.7	16.6'	GC	Great Hercules Cluster
IC 4617	16h42.1m	36°41'	15.5	1.2' by 0.4'	Gal	
NGC 6207	16h43.1m	36°50'	11.6	3.0' by 1.1'	Gal	SA(s)c
NGC 6210	16h44.5m	23°49'	8.8	14"	PN	
NGC 6229	16h47.0m	47°32'	9.4	4.5'	GC	
Alpha Herculis	17h14.6m	14°23'	3.5/5.4	4.6"	Dbl	Rasalgethi
Delta Herculis	17h15.0m	24°50'	3.1/8.2	8.9"	Dbl	
M92 (NGC 6341)	17h17.1m	43°08'	6.4	11.2'	GC	
NGC 6539	18h04.8m	–7°35'	9.8	6.9'	GC	
NGC 6605	18h17.0m	–15°01'	6.0	7'	OC	
NGC 6604	18h18.1m	–12°14'	6.5	4'	OC	
M16 (NGC 6611)	18h18.8m	–13°47'	6.0	21'	OC	Eagle Nebula cluster
IC 4756	18h39.0m	5°27'	4.6	52'	OC	

Object: Designation in Messier, NGC, or other catalog. **R. A.(2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep.:** Size in arcminutes or arcseconds, separation in arcseconds. **Notes:** Hubble type for galaxies.

The Strong Man

"Close to the polar bear and the icy north there is a figure that leans on one knee and he himself is the only one who knows the reason for this position."
Astronomica, *Marcus Manilius (first century B.C.)*



Despite the fact that the constellation known as Hercules is named after, arguably, the most famous figure in Greek mythology, the history of the star group itself is shrouded in mystery.

The Herculean figure marked out by the stars appears to us in the Northern Hemisphere as upside-down — as it did in the fourth millennium b.c., when it shone on the northern meridian (marked by the then-polar star Thuban) at midnight during the spring equinox. Southern observers see the heroic figure right side up.

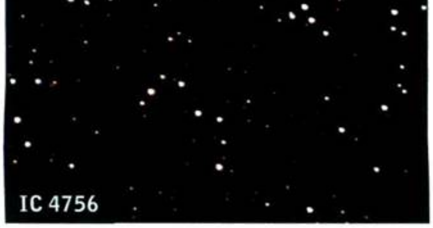
Arguably, the first to name the constellation Hercules was Panyassis (fifth century b.c.), who was uncle to the famous historian Herodotus. He reportedly wrote fourteen books about Hercules and wished to exalt yet another Argonaut to a heavenly perch.

Later, the Atlas Farnese, the famed 2,000 year-old sculpture of the Titan who carries the celestial sphere on his shoulders, represented the Hercules constellation as a nude man in a kneeling position. But it wasn't until the astronomical fables of Hyginus in 1485 that Hercules appeared clothed in a lion's skin, holding a club, and involved in mortal combat with the serpent.

In 1690, Hevelius depicted Hercules in a similar fashion but with the addition of the hero clutching the three heads of the dog Cerebrus — the last victim of his storied twelve labors. *— Paul Morledge*

often referred to as M16. The Eagle Nebula is an emission object 7,000 light-years away, and holds within its clutches an active stellar nursery. This object is similar in type to the Orion Nebula, only it is viewed from a more favorable side-on perspective. Stars belonging to M16 are extremely young — on the order of several million years.

M16 contains about a dozen stars brighter than 10th magnitude, and several dozen more that appear as cluster members through the eyepiece. Overall the size of the cluster is about 10', but immersion in starry fields makes the edge difficult to discern. The diffuse light of the Eagle Nebula engulfs the entire cluster and extends well to the south. A nebula filter shows this glowing cloud to be fully 20' across. The dark nebula that composes the body of the Eagle is seen well to the southeast of the cluster as a dark wedge against the emission nebula. Discerning the individual pillars requires large aperture and a clear night.



Rod Pommier

Slightly more than 1° to the south-southwest of the Eagle Nebula lies another open cluster, **NGC 6605**, which may require some imagination to pick out from rich starfields. It contains a couple dozen stars that are all quite bright and widely spread over a 15' field. Even if you don't detect the cluster, the area near the center of the Milky Way is swimming in gorgeous starfields and dark nebulae.

Now reset to the Eagle Nebula and pan 1.5° north to find **NGC 6604**, a much better example of an open cluster. Located in the core of an HII region, the light of these stars is dimmed by three magnitudes. A centrally positioned 7th-magnitude star outshines all the other cluster members by two magnitudes. Seen from a distance of 5,500 light-years, this star is 2,300 times brighter than the sun. In a 10-inch scope, NGC 6604 shows about 20 stars over an area 10' across. The entire cluster is embedded in an emission nebula, which shows up well as a mist around the cluster. A nebula filter shows an enhancement 5' across and about a half degree to the north of the cluster.

NGC 6539 is a small globular cluster, difficult to resolve in any telescope. With its brightest stars around 16th magnitude, a 13-inch at high magnification shows a granular appearance. A small number of individual stars are discernible in a 20-inch telescope during moments of good seeing.

At the northern edge of Serpens Cauda sits a pleasantly surprising open cluster and a rare example of a naked-eye object with an IC (*Index Catalogue*) designation. IC 4756 is a widely scattered open cluster that appears at dark observing sites as a small bright haze near the edge of the Milky Way's Great Rift. You might be able to resolve the brighter stars in 11x80mm binoculars. The best instrument to use is a rich-field telescope, which neatly frames the nearly one-degree collection of stars. This instrument reveals a beautiful collection of at least fifty 9th- and 10th-magnitude stars.

Tom Polakis is an aerospace engineer who lives in Arizona. His favorite astronomical pursuits are deep-sky observing and photography.

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Beginner's sky

Diary of a neophyte astronomer. by Jerry Burstein

Beginner's Sky

I hope many of you during the latter days of this past March and early April (which is when I'm writing this) had the opportunity, as did my daughter and I, to see Comet Ikeya-Zhang in the early evening sky. I read about Ikeya-Zhang (pronounced "ee-kay-yuh jong") on www.astronomy.com, and when we went out to look, there it was just after sundown, close to the horizon in the western sky, its tail shooting straight up.

Wow, this couldn't have been timed more perfectly, I thought. Seeing Comet Ikeya-Zhang provided the needed impetus for us to get back out viewing the night skies. It also coincided perfectly with an astronomy reading section that Amanda's second-grade class was studying in school. (Our sighting gave her something to share during science class.)

The weather warmed up enough to spend adequate time hunting the comet down with binoculars and a small telescope. And hey — it didn't even interfere that much with bedtime! From our rural outpost we were treated to some great views — on two separate nights — of this easily spotted object. (Imagine not only my excitement on getting a pretty clear look, but also the enthusiasm of an eight-year-old checking it out.)

Andrew Cooper

Of course, it didn't take long before I heard, "What is a comet anyway?" "Can they ever hit us?" "Why is it called Ikeya-Zhang?" and "When can we see more?" With the exception of knowing it was named after the two people that spotted it first (amateur astronomers Kaoru Ikeya of Mori, Shizuoka Prefecture, Japan, and Daqing Zhang of Kaifeng, in Henan Province, China), I had no clue how to answer the other questions. So we searched for assistance and discovered these answers and facts that interested us the most:

What is a comet?

Comets are clumps of rock and ice, which formed from the same material in our solar system that produced the sun and planets 4.6 billion years ago. When a comet's elliptical orbit takes it far from the sun, the low temperature of deep space keeps the rock and ice frozen. As the comet nears the sun, it heats up, emitting the fuzzy cloud of gases and dust (called a coma) that reflects the sun's rays and makes it visible from Earth. Comets appear brightest when closest to the sun. They differ from asteroids because they typically travel around the sun in a very elongated orbit instead of a more circular one. According to the shape of that ellipse, astronomers can predict a comet's return.

Can they ever hit us?

It's highly unlikely — but in 1994 when Comet Shoemaker–Levy 9 slammed into Jupiter, it left dark swirls in the cloud tops that were visible through a small telescope. Since then, we've learned that other comets have disintegrated as they neared a planet. The planet's gravitational pull causes uneven tidal forces on the near and far sides of the comet that break it into pieces. The closest Ikeya-Zhang got to Earth was about 37.5 million miles, too far away to cause a break up.

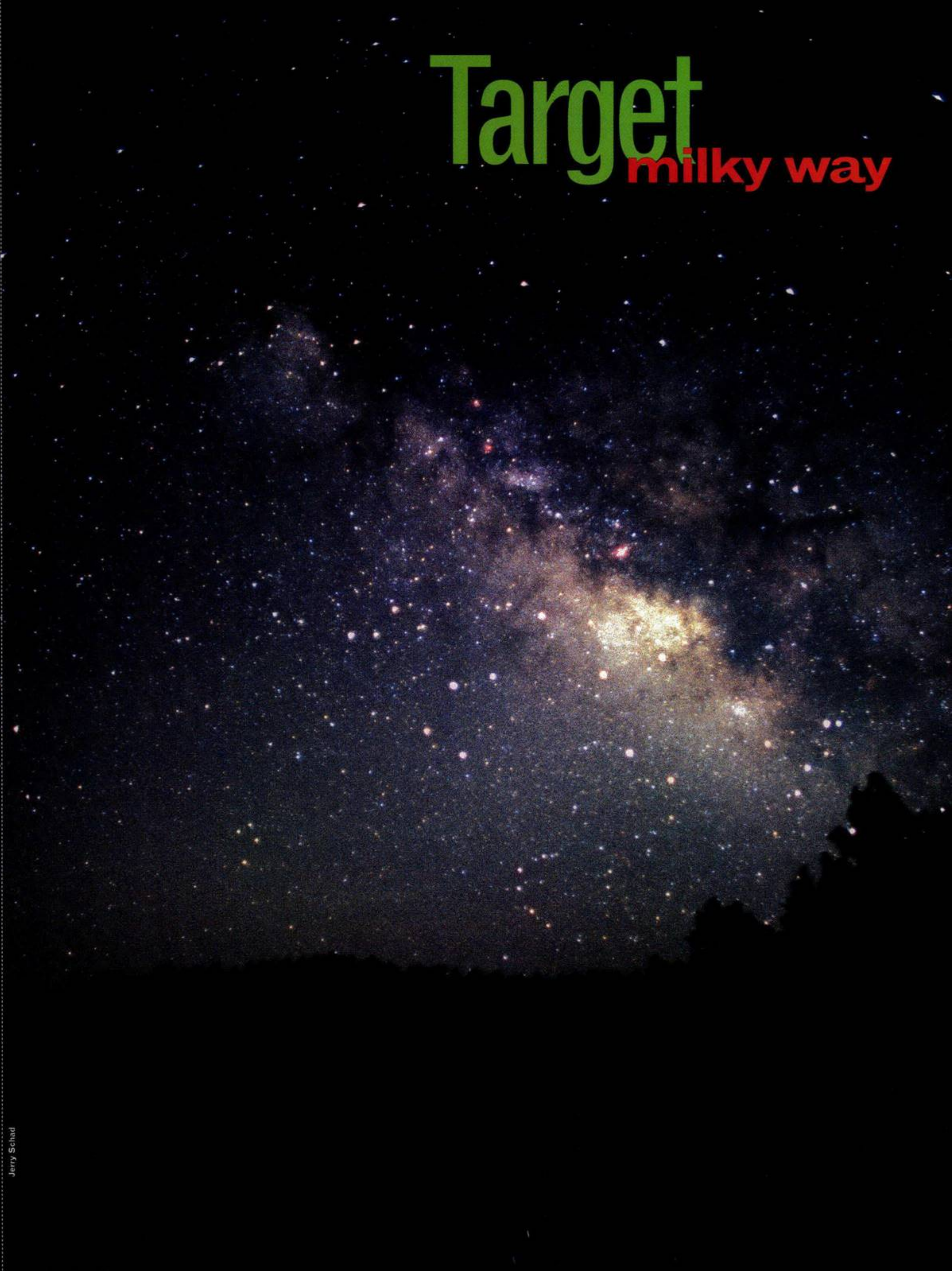
When can we see more?

One source we consulted reported that about two dozen or so comets are discovered each year. Yet almost none of these are bright enough to see with the naked eye, binoculars, or a small telescope. The year 2002 has been an exception. The best advice is to stay tuned — we may see more. After all, it took 341 years for Ikeya-Zhang to reappear. (Formally known as C/2002 C1, this particular comet was last visible in 1661, when Samurai lords ruled Japan.)

So get out and enjoy the summer nights. Amanda and I are excited about checking out the Milky Way in the southern sky. Let me know about your adventures at *jerry@astronomy.com.*

Hmmm, "Comet Burstein" has a nice ring to it, don't you think?

Target
milky way



cut along dotted line

Jerry Schad

Cleaning optics

by Phil Harrington

While the optics in a telescope should be kept as clean as possible, never clean a mirror or lens unless absolutely necessary. A little dust never hurt anything, so if that's all you see, leave well enough alone. If dirt and grime have accumulated, however, it's time to take action. Cleaning optics is not as difficult as it sounds.

Cleaning Lenses and Corrector Plates

Never use processed cotton balls for cleaning, as their fibers may actually scratch the lens surface. Also avoid bathroom or facial tissue, since they are often impregnated with perfumes and dyes. Instead, use a camel's-hair brush or a can of compressed air to remove particulate matter. When using a brush, lightly whisk the surface of the lens in one direction only, flicking the brush free of any accumulated dust particles at the end of each stroke. If you use compressed air, hold the can perfectly upright and at the distance recommended on the can.

A gentle cleaning solution is needed for removing fingerprints, skin oils, and other residue from optical surfaces. You can brew an excellent homemade solution from three cups of distilled water, a half cup of pure-grade isopropyl alcohol, and two or three drops of a mild, fragrance-free dishwashing liquid. Photographic lens-cleaning fluid is also fine. Avoid commercial window-glass sprays.

Materials for Cleaning Optics

Camel's hair brush

Can of compressed air

Photographic lens-cleaning fluid

Surgical cotton or photographic lens paper

Three or four lint-free towels

Access to a sink

Safe drying area

Homemade solution:
  One gallon distilled water
  One pint pure-grade isopropyl alcohol (Look for 91% isopropyl alcohol at your pharmacy.)
  Mild, fragrance-free dishwashing soap

Use this cleaning solution with surgical cotton or lens tissue. Squeeze excess liquid from the cotton or lens tissue until it is only damp. Gently blot the lens in short strokes — no elbow grease. Turn the cotton or tissue in a backward-rolling motion to carry grit up and away before it has a chance to rub against the optical surface. Overlap the strokes until the entire surface is clean. Finally, use a dry piece of lens tissue or cotton to blot up any residual moisture.

Clean a corrector plate following the same procedure, except for the blotting direction: Begin at the centered secondary mirror holder and move out toward the edge in a spoke-like pattern.

Mirror Cleaning

You'll probably need to remove a telescope's primary or secondary mirror to clean it, so be sure to consult your owner's manual for details. After removal, lay the mirror flat on a padded horizontal surface. Spray compressed air across the mirror to remove dust and dirt particles.

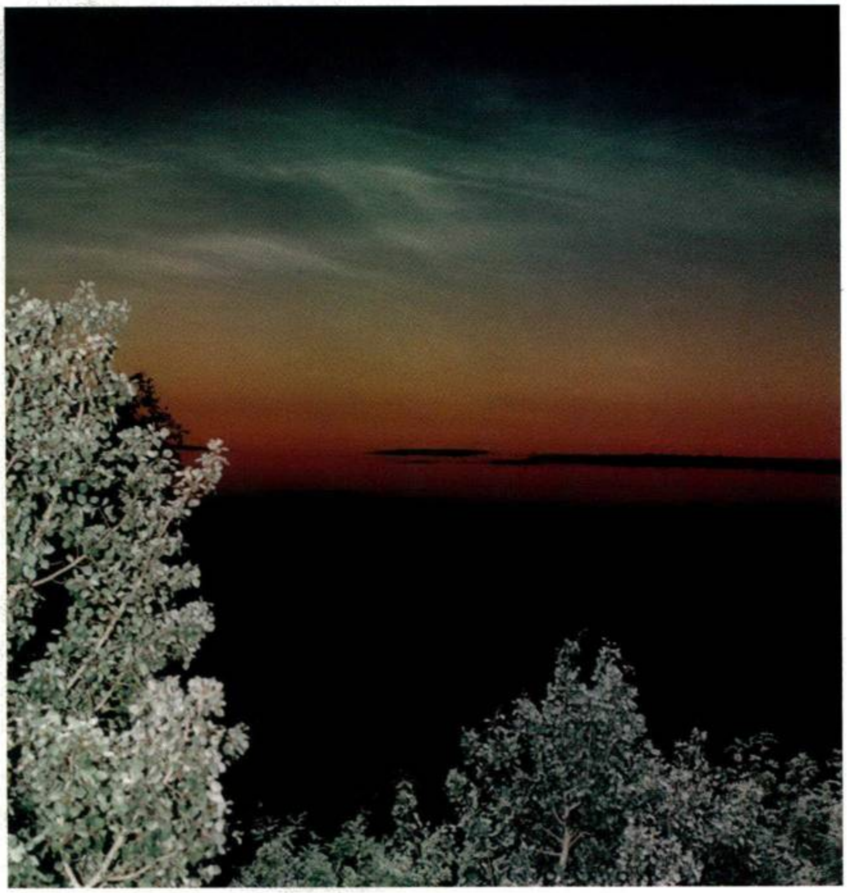
The next step involves rinsing the mirror in a sink, so be sure to line the sink with a towel just in case — Oops! — the mirror slips. Run lukewarm tap water across the mirror's reflective surface to lift off any stubborn dirt particles the compressed air may have missed. End with a rinse of distilled water. Tilt the mirror on its side next to the sink on another lint-free towel to drain.

Examine the mirror carefully. Is it clean? If so, quit. If not, fill the sink with enough tepid tap water to immerse the mirror fully, and add a few drops of liquid dishwashing soap. Carefully lower the mirror into the soapy water and let it sit for a minute or two. With a clean wad of surgical cotton, sweep across the mirror's surface ever-so-gently with the same backward-rolling motion, being careful not to bear down. If stains still exist after this step is completed, let the mirror soak in the water for five to ten minutes and repeat the sweeping with fresh cotton.

Rinse the mirror again with tepid tap water until soap-free. Then do a final rinse with room-temperature distilled water. Tilt the mirror at an angle greater than 45° with its edge resting on a soft towel so that any remaining water droplets roll off without leaving spots. Let the mirror air dry in a safe spot where no one can bump it. When it's completely dry, reassemble your telescope according to instructions.

Recollimate the optics and you're done.

For more than 30 years, Phil Harrington has been cleaning his telescope's optics only when absolutely necessary. He also writes about astronomy equipment and observing. Visit his website at: www.philharrington.net.



Sky stuff to look for in July:

Catch Venus in the early evening before it slips between Earth and the sun. Watch through a telescope as it changes phases from gibbous to a crescent shape during July.

Far Northern Hemisphere observers should be on the lookout for lacy whorls or noctilucent cloud formations in the constant twilight.

Early risers can look for Saturn in the east–northeast predawn sky.

Finally, in mid-month expect the crescent moon to jump over Regulus, the brightest star in Leo. Venus will be nearby for your early evening viewing pleasure.

Observers frequently spot noctilucent cloud displays from this vantage point overlooking Vermilion, Canada. Oscar Van Dongen

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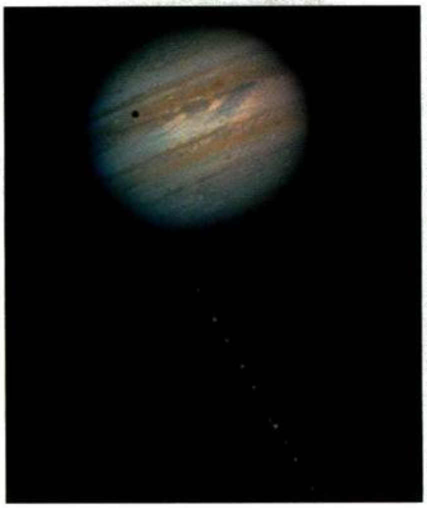
Glossary



Gravitational tidal forces caused the breakup of Comet Shoemaker–Levy 9 as it neared Jupiter.

H. A. Weaver, T. E. Smith (STScI) and J. T. Trauger, R. W. Evans (JPL), and NASA

Coma A spherical gas and dust cloud surrounding a comet's nucleus.

Comet A relatively small, sun-orbiting body composed of rock, ice, and dust whose highly elliptical orbit may take it to the edge of the solar system.

Comet tail The teardrop-shaped trail of gas and dust formed as solar radiation heats a comet nearing the sun. The tail contains neutral and ionized gas molecules that fluoresce in sunlight as well as dust particles that reflect sunlight. Its dust particles form a shorter, broader, and more curved portion of the tail, while the gaseous elements tend to stretch out in a straighter, longer shape — sometimes for millions of miles. The tail reaches maximum dimensions just after perihelion.

Gravitational tidal force The uneven force exerted on a satellite, comet, or asteroid by a much larger celestial body. It results in a stretching of the orbiting object, which sometimes results in the disintegration of that object. This is what caused Comet Shoemaker–Levy 9 to break apart before it impacted Jupiter in 1994.

Regolith An unconsolidated layer overlying solid rock on the moon, planets, and other solar system bodies. Formed from the rocky debris and dust ejected from impactors (meteors and comets).

Sublimation The change of a solid (such as ice) directly into a gaseous state (bypassing the liquid phase). This happens in the vacuum of space with comets, as the heat from intense thermal radiation and solar wind causes the icy portions of comets to "steam off" as gasses into space, forming a coma and tail that's often visible from Earth.

While you may find some new terms among these entries, many of them appear in articles throughout this issue.

Over the Rainbow

by Dale E. Mais

Spectroscopy is a key reason we know so much about the universe, both at the atomic and molecular scales and at astronomical scales. Once exclusive to professional astronomers at large observatories, spectroscopy can now be done by amateurs in the backyard. This is due to both the use of more sensitive CCD detectors and the recent availability of powerful and versatile spectrometers aimed at the amateur community. I will focus on the instrument produced by Santa Barbara Instrument Group (SBIG), the Self-Guided Spectrometer (SGS).

My primary scope for spectroscopy is a 14-inch SCT. The spectrometer is linked to the telescope with a focal reducer giving a final focal ratio of 6. The SGS appeared on the market during late 1999 and was aimed at a subgroup of amateurs with special interest in spectroscopy. It offers several novel features.

In conjunction with SBIG CCD cameras, the SGS is self-guiding in that it keeps the image of an object locked onto the entrance slit, which allows for long exposures. The light from the telescope reaches the entrance slit, which serves the function of a narrow aperture so that what is ultimately focused onto the detector is a spectrum composed of a large number of very narrow images of the slit. This has the effect of easily showing the narrow wavelength regions, which have been removed (absorption) or added to (emission) by the object of interest. The light passes through the slit and reaches the grating and ultimately the CCD camera's imaging chip. The remaining field of view is observed on the guiding CCD chip of the camera and allows viewers to select a field star to serve as a guide star once the target is centered on the slit. A wider slit option allows you to capture the spectra of faint objects at the expense of resolution.

The SGS features a dual-grating carousel, which, with the flip of a lever, allows dispersions both in a low-resolution mode or high-resolution mode. Resolution is important in spectroscopy. The greater the resolution — the more spread out the spectrum — the greater the amount of detail can be captured. Users select the region of spectrum by adjusting a micrometer dial.

Jason Ware, Plano, Texas

Jason Ware

The Wild Duck Cluster

This open cluster in Scutum, also known as M11, appeals to me as viewed in the context of its surroundings. Wide-field refractors and even binoculars show this object as a sparkle of stars among the fainter background of the Milky Way. Several dark nebulae are also visible in the area. The whole region of the Scutum Star Cloud is beautiful.

Dark Nebulae B142 and B143

Moving into Aquila brings us to a ghostly, dark "E"-shaped hole in the sky. These dust clouds block the light of stars beyond them and are visible even in binoculars from a dark sky site.

Globular Cluster Omega Centauri

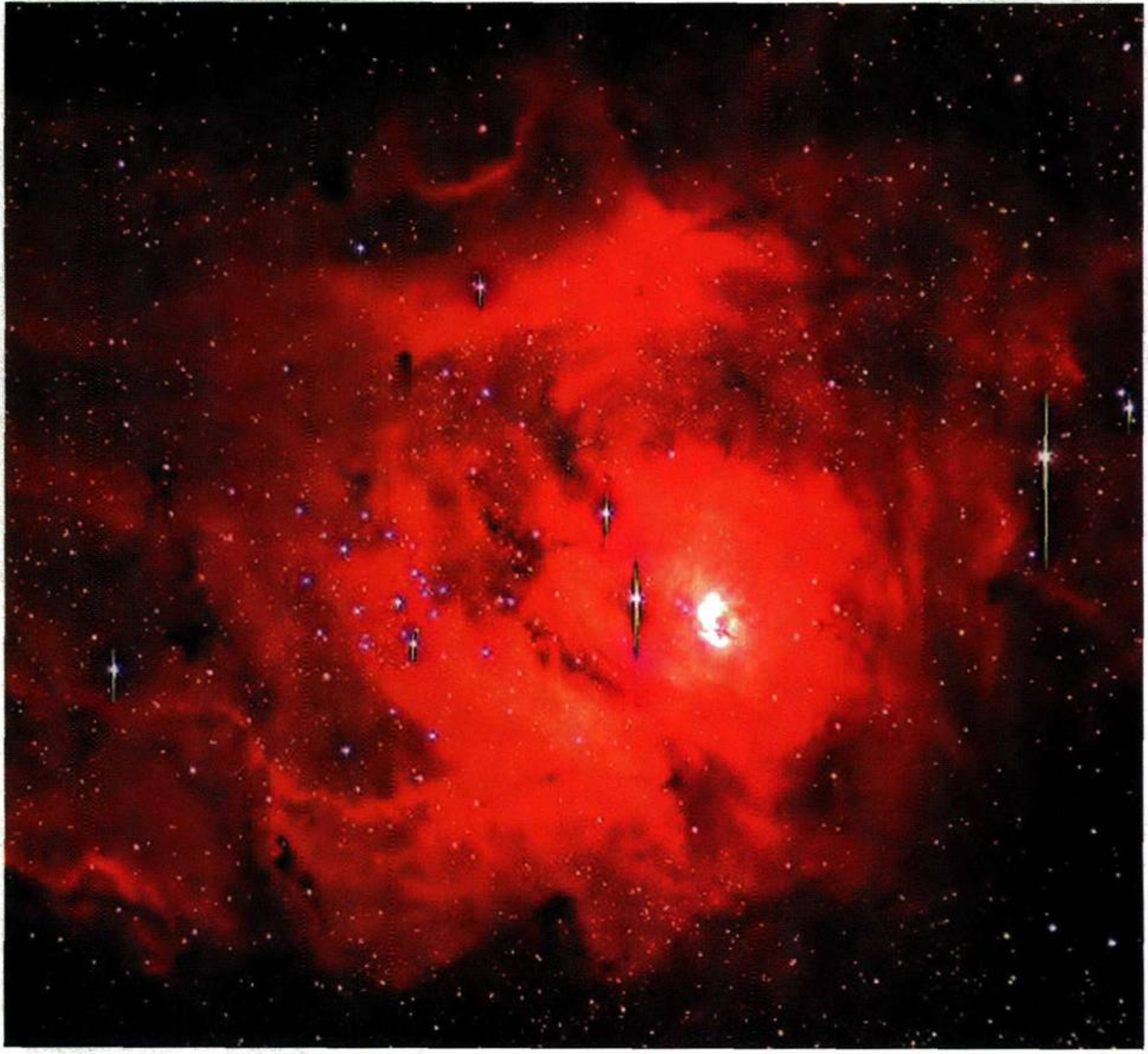
Having attended many Texas Star Parties, I've enjoyed looking at this cluster more than anything else. Nothing reminds me more of the dark West Texas skies. This cluster fills the field of my 16-inch SCT with a 40mm 2" wide-field eyepiece.

The Milky Way

Okay, this might be cheating because you wouldn't classify the Milky Way as an "object." However, if you take it as a whole, you realize it's no different than looking at a distant galaxy. People often look at my photos of galaxies and ask what the objects would look like to the unaided eye if they were much closer. I say "just look up — we live inside a great spiral galaxy that's visible every night."

The Andromeda Galaxy

You may have noticed that I chose four off-the-beaten-path objects for my first four picks. So why the very well-known Andromeda Galaxy for number five? Quite simply, it's the ultimate challenge object for an astrophotographer. The enormous range of brightness, from the blinding core to the faint outer arms, is tough to catch in a single image.

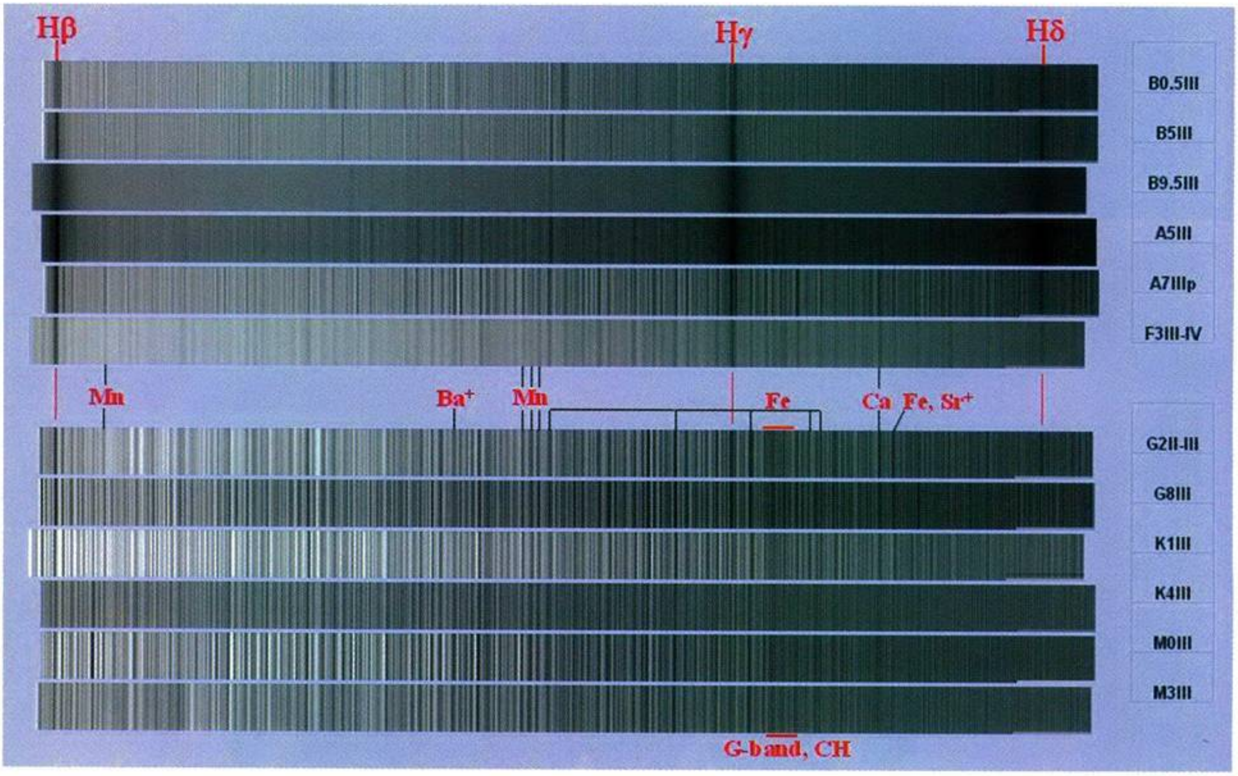


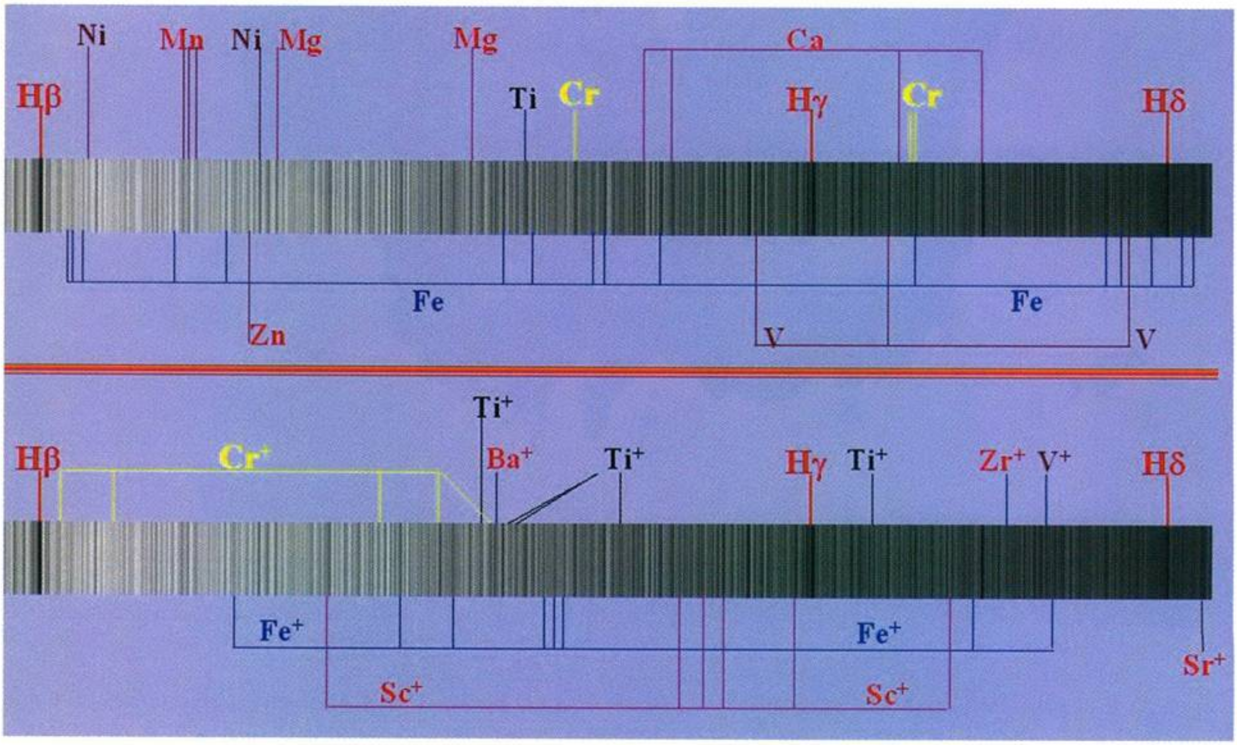
The Lagoon Nebula region offers much for backyard spectroscopists. Dale E. Mais

Capturing a spectrum is only the beginning. A raw spectrum can be digitally enhanced via a variety of software packages. The initial spectrum consists of a swath of light only a few pixels wide. I've found that a gentle sharpening routine and/or an unsharp mask produce a reasonable enhancement of features. Once I have a spectrum and have adjusted it, I can identify emission and absorption lines using the *Handbook of Chemistry and Physics.*

The SGS's low-resolution mode is useful for classifying the spectra of stars and for capturing spectra of planetary nebulae. In the high-resolution mode, many absorption lines are visible, revealing atoms, ions, and simple molecules. A good set of spectra (page 88, top) can reveal many interesting features in stars ranging from class B to M, and many lines show up — especially working your way toward the cooler stars. Each line represents a different atom, ion, or even molecule interacting with radiation in a unique way. The line's profile or shape contains information regarding the physics of the star's atmosphere. For example, buried in the line profile are clues to pressures, densities, and temperatures, some of which, with the appropriate math, can be extracted. In addition, a component of the rotation of the star often lies buried within the profile.

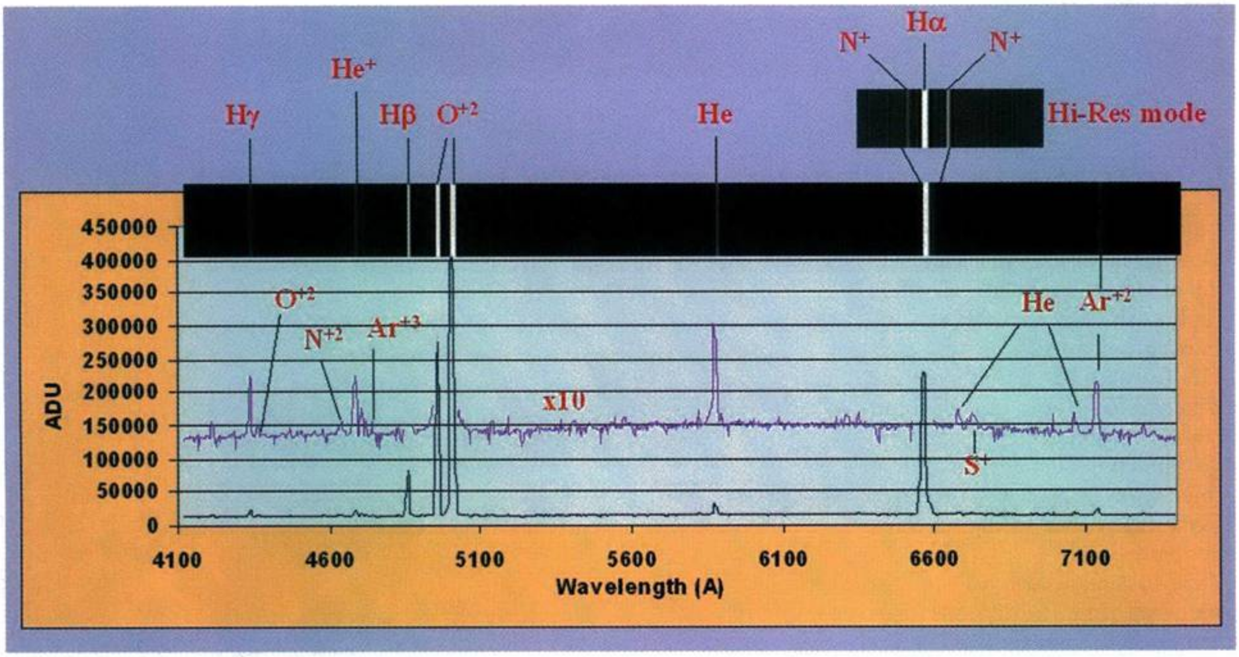
When the SGS spectrometer is used in high-resolution mode, many absorption features can be observed in stellar spectra, particularly in cooler stars. A high-resolution spectrum of Theta Cygni (page 88, bottom), an F-type main sequence star, for example, reveals a lot. Iron, barium, and





chromium are dominant features. The *Handbook of Chemistry and Physics* lists more than 21,000 lines for all the elements. Identifying the lines remains something of an art. Since the instrument is only at best able to resolve 1 to 2 Angstroms in the higher resolution mode, some criteria must be used to eliminate many potential lines or, as is often the case, a line may represent a blend of two or more lines.

Under certain conditions, matter can emit light at specific wavelengths. This process is called emission and is most often observed in gaseous clouds in space. An emission line spectrum (opposite page, top) reveals a lot about an object, like the Saturn Nebula (NGC 7009). The main body of the line spectrum was obtained in the low-resolution mode so that a majority of the emission features across the entire visible range could be observed in a single picture. A higher resolution spectrum is shown in the upper right centered at the Hα line. In high-resolution mode, three components are seen to make up this strong emission, Hα and two lines of



Above: The spectrum of NGC 7009, the Saturn Nebula, showing wavelengths excited by the hot central star. Opposite page, top: Classification of stars based on their spectra. The author recorded spectra from stars of classes B to M. Opposite page, bottom: Spectra of atomic (top) and ionized (bottom) elements in the star 13 Cygni; the blue region of the spectrum runs from Hβ to Hδ. Dale E. Mais

N^+, singly ionized nitrogen atoms, which flank Hα.

Opportunities for backyard research abound. For example, photometrists often monitor the changes in the brightness of stars using filters that allow a broad band of wavelengths to pass, such as red or blue wavelengths. These same stars could be monitored for spectral line changes. With the SBIG spectrometer, it should be easy to monitor these stars in the Hα region.

Shell stars comprise another similar class; one of the brightest examples is Pleione in the Pleiades. I try to get a spectrum of this star at every opportunity because it is always doing something interesting.

Another class of stars, which could be monitored profitably by amateurs, is the Herbig Ae stars. A few giant eclipsing binaries show dramatic spectral changes as the eclipse starts and ends because the companion star is shining through the giant star's atmosphere. This happens with a wide variety of stars, such as the well-known VV Cephei and Zeta Aurigae.

The future is certainly bright — or at least colorful — for amateur spectroscopy. As far as the SGS is concerned, future versions will offer the option of having a higher dispersive grating. This will improve the identification of lines by spreading the spectrum out by a factor of three compared to the current high-resolution grating. We will see this evolve quickly as a new field in which amateurs can do something tremendously special.

Dale E. Mais is an endocrinologist who spends time in the observatory along his orange grove in Valley Center, California.

Challenging Comets/July 2002

In any month, usually several comets glow brightly enough to become visible to those with large telescopes. Here are coordinates and magnitudes:

7P/Pons-Winnecke

July 1	23h54.5m, –27°46', 11.1
July 11	0h15.4m, –31°48', 11.4
July 21	0h30.0m, –35°41', 11.8
July 31	0h37.8m, –39°17', 12.1

C/2002 F1 (Utsunomiya)

July 1	7h06.1m, –15°03', 12.1
July 11	7h24.5m, –19°18', 12.6
July 21	7h41.9m, –23°21', 13.1
July 31	7h58.4m, –27°17', 13.6

22P/Kopff

July 1	11h59.6m, 5°15', 13.7
July 11	12h11.3m, 3°45', 13.4
July 21	12h24.6m, 2°04', 13.2
July 31	12h39.6m, 0°15', 12.9

C/2002 E2 (Snyder-Murakami)

July 1	13h44.8m, 80°00', 13.0
July 11	13h14.9m, 78°13', 13.3
July 21	13h04.0m, 76°30', 13.6
July 31	13h03.7m, 74°59', 13.9

C/2001 N2 (LINEAR)

July 1	17h31.8m, 17°51', 13.2
July 11	16h57.1m, 14°32', 13.3
July 21	16h27.6m, 10°45', 13.3
July 31	16h04.3m, 6°58', 13.5

C/2000 WM1 (LINEAR)

July 1	16h23.6m, 35°18', 13.7
July 11	16h14.3m, 34°06', 14.1
July 21	16h08.5m, 32°41', 14.4
July 31	16h05.9m, 31°09', 14.8

C/2000 SV74 (LINEAR)

July 1	9h40.9m, 81°36', 14.0
July 11	10h48.9m, 78°28', 14.1
July 21	11h31.0m, 74°57', 14.1
July 31	12h00.6m, 71°21', 14.1

PRODUCTS

MaxView 40 Adapter Minimizes Vignetting

► ScopeTronix of Cape Coral, Florida, offers astrophotographers the MaxView 40, an eyepiece and variable projection adapter for digital cameras. Its fully multi-coated eyepiece adjusts to any height for proper eye relief and more comfortable viewing.

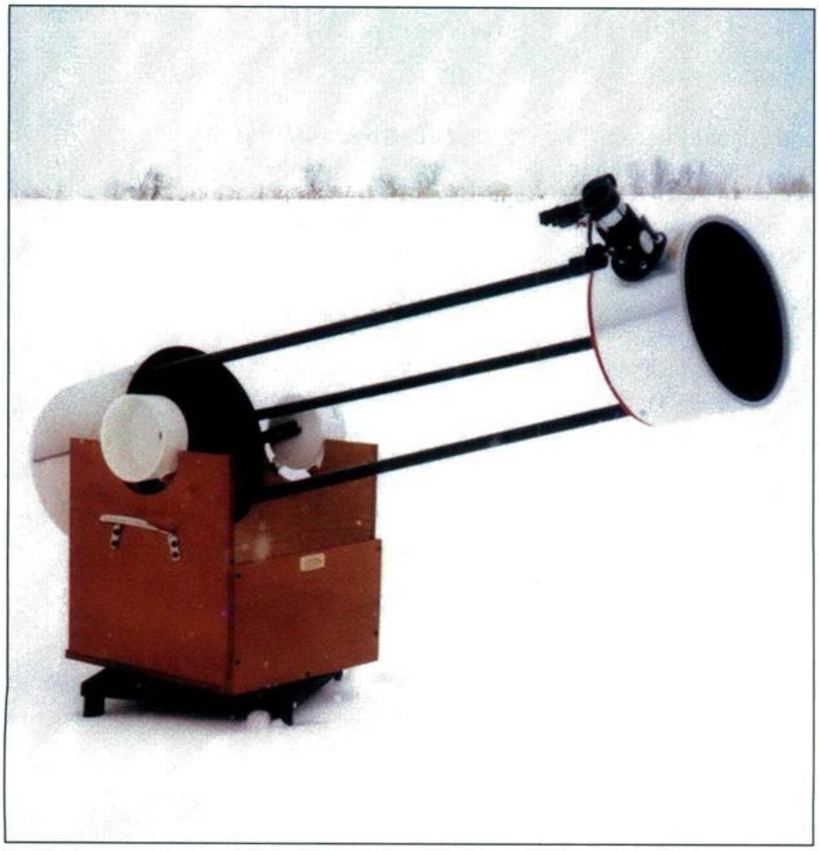
Thanks to a tight coupling between camera lens and eyepiece, the MaxView 40 reduces vignetting effects that occur in digital cameras with larger lenses.

The MaxView 40 threads fit most cameras with the proper step ring. Its 1.25" eyepiece offers the largest possible diameter lens that fits through a "T" thread. While it may not totally eliminate vignetting in all cases, the unit will make a substantial difference for astrophotographers. Patent pending.

Priced at $129.95 plus shipping.

Scopetronix Inc., 1423 SE 10th Street, Unit 1A, Cape Coral, FL 33990; phone/fax (239) 945–6763; website, www.scopetronix.com; e-mail, info@scopetronix.com.

SCOPETRONIX MAX



Star*Tron II Series Truss Tube Telescope

The Star*Tron II Series Dobsonian reflector truss tube telescope is available in three models: 6-inch, 8-inch, or 10-inch. Each of these North*Star*Systems instruments features hand-figured parabolic Pyrex mirrors, quality ¾" plywood Dobsonian mounts with Teflon altitude and azimuth bearings, and rack-and-pinion focusers with a 2.25" focus range.

Every telescope arrives completely assembled. Just adjust wing-nut screws for precise optical alignment of the primary mirror cell, look through the 1.25" multicoated 12.5mm Plössl eyepiece, and enjoy breathtaking views of stars, planets, galaxies, nebulae, and more.

Delivery time varies from three to six weeks per order. Every telescope comes with a 100 percent money-back guarantee within 30 days (less shipping).

Cost of scope is based on size and shipping weight: 6-inch f/8: $299 plus $29 s/h; 8-inch f/6: $389 plus $39 s/h; 10-inch f/5: $539 plus $59 s/h. Also available in 12.5-inch and 16-inch sizes. Call for prices.

*North*Star*Systems, P.O. Box 99, Ellenburg Depot, New York 12935; (518) 594–7250; fax: (518) 298–3520; website, http://blastoff8.tripod.com/northstarsystems; e-mail, cenname@westelcom.com.*

Tele Vue's New Everbrite Mirror Diagonal

Tele Vue Optics now offers a smaller-size Everbrite mirror diagonal for telescopes that accept 1¼" diagonals. Based on the design of its 2" Everbrite mirror diagonal, the new diagonal incorporates the same sturdy body design as its larger cousin and features the same 99 percent reflectivity, thanks to its broadband dielectric coating.

This special coating and the mirror's flatness contribute to its extremely high reflectivity. The unit includes a captive lock screw and a safety undercut barrel, as well as anti-reflection and filter threads. Its 1½" eyepiece barrel depth permits full parfocal use of all 1¼" Tele Vue eyepieces. Machined from a single block of black anodized aluminum, the barrels can't accidentally unscrew. Mirror cleaning is easily accomplished by removing the solid back. Total weight is only six ounces (171g). Priced at $190.

Tele Vue Optics, Inc., 100 Route 59, Suffern, NY 10901; (845) 357–9522; website: www.televue.com.

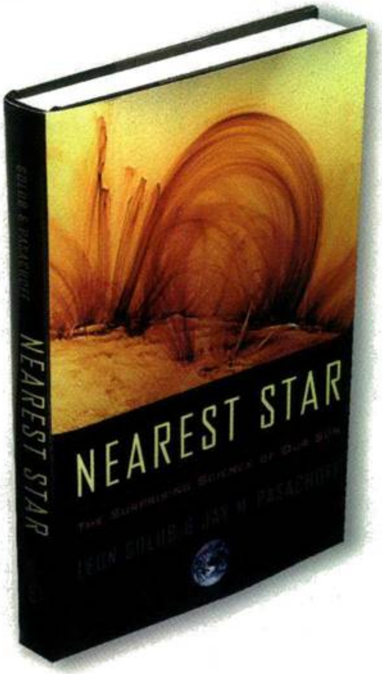
TeleVue
Everbrite Dielectric
TeleVue
Everbrite Dielectric

BOOKS

Nearest Star: The Surprising Science of Our Sun

Leon Golub and Jay M. Pasachoff, 267 pages, Harvard University Press, Cambridge, Massachusetts, 2001; ISBN 0–674–00467–1; hardcover, $29.95.

Many ancient cultures worshipped the sun as a god, a giver of life. While most of us have long given up the notion of the sun as a deity, we cannot deny that life on our planet owes its very existence to it. The sun provides Earth with heat and light. Plants produce the oxygen we breathe with the help of sunlight. The complex interaction between the sun's radiant energy and our atmosphere is responsible for our "hospitable" environment. Despite our apparent good fortune — having just the right place in the solar system around just the right kind of star — the sun really is just an "average" star, only one among billions in the Milky Way Galaxy. All these other stars, however, appear to us as mere points of light in the sky, even in the most powerful telescopes. The proximity of our sun provides us with a unique opportunity to study a star up close.


NEAREST STAR
The Surprising Science of Our Sun
Leon Golub & Jay M. Pasachoff
NEAREST STAR
Golub & Pasachoff

In *Nearest Star*, two of the world's leading solar scientists give us a fascinating and informative account of our sun as a star. Leon Golub, an astrophysicist at Harvard University, and Jay M. Pasachoff, Field Memorial Professor at Williams College, trace the history of solar studies from the first visual observations to the latest state-of-the-art space missions. The authors examine the basic physical parameters of the sun and its origin and evolution. They discuss in great detail the structure of the sun, how it works, and how this information is derived both from the things we can see and those we can't. There is a wonderful discussion of eclipses and their scientific value, replete with black-and-white images. Their grand finale is two chapters in which they examine the sun's role in shaping the climate on Earth and the effect of space weather on Earth.

Golub and Pasachoff do not simply present an account of scientific fact. Rather, they show us how the process of science works. For example, in discussing the structure of the sun, they examine the concept of stellar opacity — which can be thought of as a resistance of matter to the flow of radiation. They explain how opacity effects lead to an observed darkening of the sun's disk going from the center out to the limb, an effect called "limb darkening." They also show how opacity affects what is seen in the region of spectral lines such as the calcium H and K lines and how these opacity effects are used to probe the structure of the sun at various depths. Throughout, the authors emphasize why and how we study the sun at many different wavelengths and what has been discovered by looking at the sun in each of these wavelength regimes.

Nearest Star is a delight to read. Golub and Pasachoff transmit not only their obvious expertise but also a genuine affection for the subject. The book is richly illustrated with both black-and-white images and a nice selection of color plates; it also has a necessary glossary of physics and astronomy terms. A particularly nice feature of *Nearest Star* is the critical examination of just how the sun influences Earth's climate and the role of both industrial emissions and solar factors on climate changes.

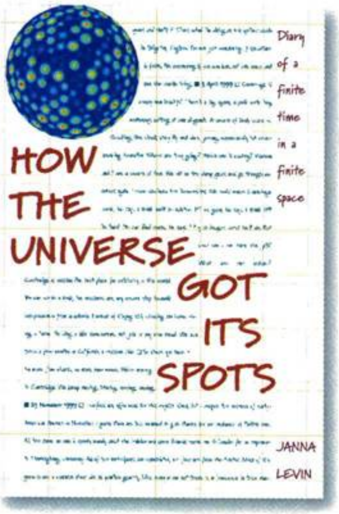
Nearest Star will surely leave you with a renewed appreciation for the beauty, complexity, and importance of our nearest star, the sun. — *Jennifer Birriel, Morehead State University*

How the Universe Got Its Spots: Diary of a Finite Time in a Finite Space

Janna Levin, 208 pages, Princeton University Press, Princeton, New Jersey, 2002; ISBN 0–691–09657–0; hardcover, $22.95.

"You could say this is the story of the universe's topology," Levin tells us at the start of *How the Universe Got Its Spots.* You could also, as Levin does, "consider this a kind of diary from my social exile as a roaming scientist."

These two strands of thought are threaded through this unusual hybrid and offer an account of cosmologists' current views on the shape of the universe interwoven with the isolated and itinerant lifestyle of an academic scientist. Levin's attempt to integrate these two genres is always interesting, if not always seamless.


Diary of a finite time in a finite space
HOW THE UNIVERSE GOT ITS SPOTS
JANNA LEVIN

How the Universe got Its Spots' peculiarity owes much to its strange genesis. "The letters that turned into a diary are being turned into a book," Levin informs us in the epilogue. These unposted letters to her mother, Sandy — the "you" in this second-person narrative — were written over a two-year period from 1998 to 2000.

Levin, an Advanced Fellow in the Department of Mathematics and Theoretical Physics at Cambridge University, is one of a handful of contemporary cosmologists working on the theory that our universe is finite, curved in a higher dimension, and much smaller than it appears. In the early chapters, the expository strand of the book reads as a brief history of spacetime, taking us smoothly from Copernicus to Einstein.

There is, Levin admits, a certain Chinese-whispered dubiousness about this oft-told story, "But I'm no historian and it makes a nice tale." Such admissions — like the confession that her hero worship of Einstein might be based on illusion — show a mind always straining against orthodoxy.

In its course, *How the Universe Got Its Spots* touches on Theories of Everything, and on theories of everything else. Number theory, relativity theory, quantum theory, brane theory, string theory, chaos theory: All are jigsaw pieces urgently thrown together by a mind intent on picturing finality. Levin's casual comment that, "This has been an unsatisfyingly incomplete course through topology" could almost stand as an incisive critique found in much of the book's early exposition.

But once Levin arrives at her heart's theme — the shape of the universe and how we might soon measure it — the descriptions become models of enthusiasm and clarity.

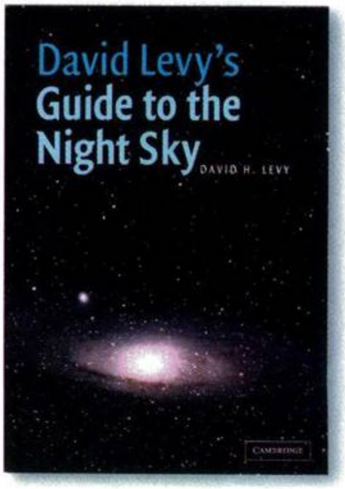
Juxtaposed to this element of public exposition is that of private confessional, whose alternative title could have been *The Loneliness of the Long-Distance Thinker.*

While Levin's self-imposed exile in England produces some amusing travel writing, much of this aspect of the book is very somber. "Some of the great mathematicians killed themselves," the author tells us in her first sentence, placing herself in a scientific tradition of madness and suicide that becomes a sporadic but unsettling theme throughout the book.

Levin takes few pains to protect her own privacy, documenting her boyfriend's breakdown, and their subsequent breakup, in simple, direct prose, and insisting on embracing responsibility: "My work killed us, but I don't know how to quit."

When an academic colleague's wife commits suicide, Levin's thoughts are characterized by a kind of lyrical fatalism: "Our partners follow us on these jarring trajectories like the jagged flock of birds and many of us have watched the light go out in our companions' eyes."

Often elegiac in tone — like a premature swansong from a young scientist with much to say — *How the Universe Got its Spots* is a genuine attempt to break down barriers, both intellectual and emotional, between scientists and their wished-for audience. — *Ken Grimes and Alison Boyle are science writers based in London, England. Their articles have also appeared in* New Scientist, BBC Science Online *and* New Statesman.



David Levy's Guide to the Night Sky

David H. Levy, 337 pages, Cambridge University Press, New York, 2001; ISBN 0-521-79753-5; softcover, $24.95.

This is a guide for stargazers written by someone who is arguably the stargazer of our generation. Even though he is best known for the discovery of 21 comets — including Shoemaker-Levy 9, which crashed into Jupiter in 1994 — for more than 40 years and in over 8,000 observing sessions, David Levy has practiced nearly every aspect of amateur astronomy. Levy shares his tremendous knowledge, interjecting it with his passion for the hobby and his own very personal experiences. The result is a comprehensive introduction to the night sky. Although intended for novices, *David Levy's Guide to the Night Sky* is a welcome addition to the library of any amateur astronomer.

The book opens with basic information on the Milky Way, the planets, celestial coordinates, and star charts. A chapter on naked-eye astronomy covers topics as diverse as aurorae, sunspot tracking, and variable stars. Another chapter covers the ever-popular topic of meteors. This lively introduction invites the reader into the real substance of the book — telescope observing — which is treated in increasing order of difficulty.

Reflecting on his own first serious observing project (a moon-mapping exercise given to a preteen David Levy when he arrived at the Montreal Center of the Royal Astronomical Society of Canada), a comprehensive section on the moon follows, the core of which is a day-by-day listing of lunar features. Levy makes a compelling case that the moon is a destination that is alive, and invites us along on his "picnic in the shadow of Copernicus's central peak."

Chapters on the sun and planets, including a lively account of the Shoemaker-Levy-9 episode, bring us to the midpoint in Levy's guide.

In a chapter on comets, we learn how Comet Levy 1987a was discovered while the author was writing one of his many other books.

His deep-sky section includes recommended targets for city skies and dark skies, as well as an object-by-object rundown of the 110 Messier objects. Moving outward in the celestial realm are double and variable stars. Chapters on film and CCD imaging provide gentle introductions to these technical topics, with eclipses and occultations closing the universal tour.

Levy is not only a master astronomer, but also an educator and a poet. In an epilogue, he gives us tips on teaching astronomy to children. He also presents us with a collection of literary quotations that complement the epigraphs sprinkled throughout the book.

A listing of his own favorite 20 celestial objects ends the book and provides a fitting summary of the journey he has taken us through, at the same time confirming the breadth and wonder of our universe.

For all of its strengths, the book is somewhat lacking in graphical support; while basic star charts are included, readers will have to turn elsewhere to find the exact locations of the Messier objects.

Also, despite the extensive chapter on telescopic lunar observing, it was surprising to find only a simplified version of the hand-drawn moon map Levy prepared as a teenager.

David Levy's Guide to the Night Sky is an updated version of *The Sky: A User's Guide*, published in 1991, with new sections on computer-controlled telescopes, CCD astronomy, and Levy's 20 favorites. Yet, the updates are incomplete, since, for example, no mention is made of CCD autoguiders, and visual filters receive only cursory treatment. Perhaps these minor shortcomings will be addressed in the next update.

All in all, Levy succeeds admirably in writing a single volume from which a wide gamut of amateur observers will benefit. Even experienced observers will learn something new about some aspect of their hobby, and all readers will catch and retain the contagious excitement Levy uniquely conveys. — *Rajiv Gupta is the editor of the* Observer's Handbook, *published annually by the Royal Astronomical Society of Canada.*

An Intimate Look at the Night Sky

Chet Raymo, 242 pages, Walker and Company, New York, 2001; ISBN 0-8027-1369-6; hardcover, $26.

It's rare for a general astronomy book to offer a practical observing course (mixed with astronomical history) that also captures the majesty of the night sky with such compelling style that you won't want to put it down.

And so, send kudos to Chet Raymo, for he does exactly that in *An Intimate Look at the Night Sky.*

AN INTIMATE LOOK AT THE
Night Sky
CHET RAYMO

Everything seems right here, including the size, heft, glossy pages, and choice of a silver book jacket that catches your eye like a glint of starlight. As you progress through the chapters, however, the physicality of sitting passively and reading falls away, leaving you totally absorbed in the message. If it's daylight, you'll hope for the hours to fly by so that you can take your turn gazing at the stars with newfound knowledge and appreciation. If it's nighttime, you'll struggle with the dilemma of having to stop reading in order to experience the drama above.

Raymo, a professor of physics and astronomy at Stonehill College in Easton, Massachusetts, celebrates the interwoven connection of astronomy with religion, philosophy, and history, leaving you with what feels like a sensual connection to the heavens. For instance, he urges stargazers to immerse themselves in the observing experience: Begin far from city lights, eyes closed, stretched out on a lawn chair or blanket with Joseph Haydn's "The Creation" oratorio playing on a portable CD player. After the voices say, "And there was light," open your eyes as the music cues to fortissimo — an audible Big Bang accented by your view of the starry dome.

Raymo's reader-friendly attitude lends insight into why the Big Bang theory developed in the first place, explaining the reasoning behind it without using scientifically intimidating language.

Twenty-four star maps detail what you can expect to see and when to look for it. Raymo's star maps do more than just point out constellations, however: Each is paired with a "What to Imagine" map that offers insight into why that particular sky locale is important — stuff that not only makes you remember what you saw, but also provides fodder for more imaginative pondering at some later time.

The book's four sections are divided by seasons, each with three chapters that explain some aspect of astronomical science. In addition to the star maps, expect a striking black-and-white astronomical image of a planet, nebulae, galaxies, star cluster, and the like.

But there's more, including two appendices: one lists which planets are visible every year until 2021; the other gives the peak annual dates for meteor showers. A short glossary defines terms found throughout. Book, software, and website resources, as well as photo captions, complete the round-up of additional information.

Anyone with children knows how much they enjoy rereading their favorite books and watching the same video over and over. Raymo's prose will undoubtedly compel many adults to do likewise with this tome. Like a mountaintop night with perfect seeing, *An Intimate Look at the Night Sky* beckons your return for an experience worth savoring. — *Carol Ryback, associate editor*

(continued on page 96)

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Webweaver Picks

By Richard J. Bartlett

Most of us remember our first scope. Like an old friend, it showed us the universe and brought the stars just a bit closer. But have you ever considered making your own scope? With some help from the Internet, you could do just that. Just think of July's warm summer days and long twilights as the perfect time to brush up on your woodworking skills.

While people have been making telescopes for hundreds of years, John Dobson revolutionized the art of telescope making in the 1950s. The Dobsonian mount is named in his honor.

Learn more at http://quanta-gaia.org/dobson/. This page provides links to some of Dobson's many essays. The subjects predominantly concentrate on the origin and nature of the universe, but Dobson isn't known simply for his telescopes and his ruminations on the cosmos. He's also famous for bringing the cosmos to the general public, and for co-founding the Sidewalk Astronomers — a group of volunteers that takes scopes into the streets, schools, and museums, allowing passersby to view the moon and planets as never before.

The California-based group has branches in Los Angeles and San Francisco. Check out its homepage at www.sidewalkastronomers.com. The site gives information about upcoming events and astronomical news. If you're feeling creative, it also links to instructions for building your own Dobsonian.

The Telescopes In Education website, — http://tie.jpl.nasa.gov/tie/dobson/ — includes a step-by-step guide that makes telescope building from scratch seem less daunting. Not only will you find the instructions you need, but also plans for 8- and 10-inch scopes. Each of the pages contains diagrams reproduced from material published by John Dobson.

Ray Cash, a member of the San Francisco branch of the Sidewalk Astronomers, maintains the pages for http://members.aol.com/sfsidewalk/cdobplans.htm. Start small with the plans for a 6-inch Dobsonian, which are downloadable in Adobe Acrobat format. Images and FAQs from amateur telescope builders appear as well.

Find more helpful advice on the ATM Page — just point your browser to www.atmpage.com/. Created as a resource for both beginners and experts, the website is still under development. Online articles cover scope design, mirror making, motor drives and mountings. Other pages include a comprehensive list of books, magazines, and vendors of parts and materials. You'll also find links to websites detailing observatory plans and CCD photography. If you've built a few scopes yourself, share your wisdom, as unsolicited articles are welcomed.

Similarly, www.telescopemaking.com covers every aspect of the hobby. The website introduces the theory, provides plans, and gives instructions on how to build that perfect scope. You'll also find links to the many retailers who can supply parts, tools, product reviews, and astronomical news.

Telescopes In Education (TIE)

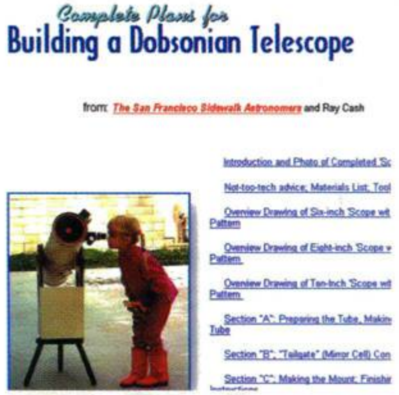
TIE User Guide & Workbook · Build a Dobsonian Telescope

Heath Gibson's Variable Star Analysis

Plans For Building a Sidewalk Telescope

ere a million amateur astronomers with telescopes, and they were willi
and people each look through their telescopes, there would be a chanc
people in the world who wanted to see to see."
John Dobson

Regardless of their expertise, everyone who's tried his or her hand at telescope making has asked for advice at some time or other. The Internet puts you in touch with literally thousands of experts, almost instantaneously. If you need help, or if you've got a problem, the Amateur Telescope Makers (ATM) website at www.atmsite.org/ has a multitude of pages and links covering all aspects of telescope making. All the information was submitted by amateurs from around the globe. Search by author, keyword, or view the articles in chronological order.



Complete Plans for
Building a Dobsonian Telescope

from: The San Francisco Sidewalk Astronomers and Ray Cash

Introduction and Photo of Completed 'Sc

Not-too-tech advice; Materials List; Tool

Overview Drawing of Six-inch 'Scope wi
Pattern

Overview Drawing of Eight-inch 'Scope w
Pattern

Overview Drawing of Ten-inch 'Scope wi
Pattern

Section "A": Preparing the Tube, Makin
Tube

Section "B": "Tailgate" (Mirror Cell) Con

Section "C": Making the Mount; Finishi

The ATM Mailing List FAQ at http://home.attbi.com/~dcass/atmfaq/atm-faq.htm, compiled by Tim Poulsen and Dan Cassaro, is basically an online textbook that uses the advice and techniques of its contributors. As such, it provides an invaluable hands-on resource.

For a more direct approach, post your query on the ATM discussion forum. If any of the other visitors to the website can help, they'll reply below your original question. The forum is used daily so don't be shy — go to www.astronomy.net/forums/atm/ and start asking.

You might wonder how long it takes to build a scope. Mike Rawlings from Driffield, England, built his 12-inch Dobsonian reflector in September and October 2001. Visit his website at www.brid-rd.freeserve.co.uk/recreation/Astronomy/Scope_Building/building.htm. In addition to the step-by-step account, Mike states how long each stage took to complete, so you can plan the process properly.

Look at some other amateur telescopes at www.crickrock.com/cgi-bin/webring/list.pl?ringid=TelescopeMaking. You'll find at least 161 websites to satisfy your curiosity. They're not listed in any particular order, so click through them one by one. For example, visit Ed Stevens's website at www.flyingscopes.com.

And remember, if you get around to building your own scope, you may find it opens the door to a much larger view of the universe.

Visit Richard's StarLore website at http://www.starlore.net.

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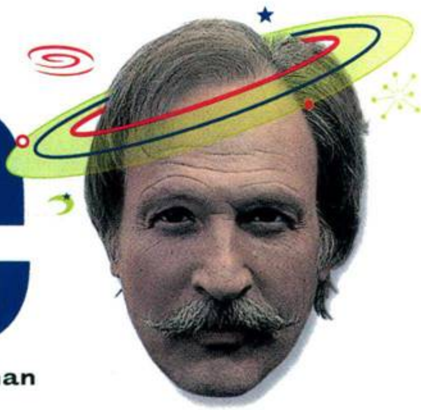

by Bob Berman

The Forbidden Light

One of the strangest items in the cosmic inventory is also among the most overlooked. Maybe this month can bring deserved attention to the curious Crab Nebula (M1) and the mind-boggling neutron star that hovers at its heart.

Neutron stars don't get much mention these days despite being fairly new to us, having been discovered only 35 years ago. To the public, neutron stars don't seem as morbidly fascinating as black holes, nor are they as capable of fully warping spacetime. The media shy away from runner-ups and wannabes, while fashion may also contribute to the dearth of attention paid to these tiny, bizarre suns. That's a shame. It's like ignoring a lizard-man sitting next to you at the movies just because a pterodactyl is in the parking lot.

This story really started before dawn on July 4, 1054, when a dazzling star abruptly appeared between Betelgeuse and Capella. As bright as Venus, it blazed for a year and was duly noted by observers in China, and duly ignored in the West where alterations in the heavens were incompatible with the prevailing theology. Now, nearly a millennium later, every telescope user can see the result of that destroyed sun: The Crab Nebula.

It's easy to locate in early July — if you're willing to get up, like its discoverers did, at 4:30 A.M. Back then, no planets occupied this Taurus region, unlike now when Saturn and Mercury meet very near the Crab, low in the east. Better still are the final ten days of the month, when Saturn and the twisted fuzzy nebula share the same low-power telescope field. (On the morning of the 25th, Saturn's moon Titan will seem to float in the nebula). Late July also finds them much higher up in nicely dark predawn skies.

Talk about weirdness, consider this: You've got a floating ball surrounded by unattached rings — a sight like nothing on Earth. Then alongside Saturn and way behind it hovers a spooky glow with a palpably alien quality. It's not starlight, not sunlight, not reflected light. Its origin is not heat, nor nuclear energy. This glow of the Crab Nebula comes from an exotic phenomenon bearing a wonderful name: forbidden radiation.

Forbidden radiation looks unearthly to us because it's so totally unfamiliar. Even our best labs can't reproduce it — hence the name. It appears when isolated atoms have been excited by synchrotron radiation, which is generated by frenzied electrons whipped to near lightspeed by unthinkable magnetic fields. If you're picturing the kind of magnetism that makes compass needles wobble, think again. The magnetic field near the Crab is 900 billion times stronger than Earth's. It blasts electrons into violent spiraling geysers that defile any atoms in their way. It would rip that compass right out of your hand.

Dwelling in a harder vacuum than we know how to create, the region's oxygen atoms get doubly ionized into a unique metastable state where they squirm uncomfortably for hours. Finally, their extra, unwanted energy is released in maneuvers so improbable, they never occur in our own cosmic neighborhood. Zap, floods of green forbidden light stream away, a strange turquoise energy visible through scopes of 12 inches or more. Even small instruments show it well, though too faintly to stimulate our retina's color machinery.

But this is just the cloak, merely the framework surrounding the inner sanctum of singular strangeness. Now we get to the heart of the nebula, the astounding object creating that magnetic field and forbidden radiation: the Crab Pulsar.

At first, "pulsar" seems simple enough. It's a tiny, hard neutron star whose magnetic poles sweep past our line of sight with each rotation. Like a lighthouse, it delivers a quick burst of energy with every turn — in this case 33 times a second. Its light looks visually steady because nobody can differentiate so many flashes per second, more than those from a movie projector.

The intense magnetic field acts as a drag, a brake, and is slowing the wildly spinning star while-U-wait. By the year 4000, the Crab Pulsar will whirl just 17 times a second — a flickering finally noticeable through amateur telescopes.

This insanely spinning object, this spherical remnant of that unfortunate sun that blew itself to Kingdom Come on the Fourth of July a thousand years ago, actually exploded a millennium before the first Pyramids. Some 5,000 light-years away, the subatomic wreckage traveled for 50 centuries before slamming into us.

It would have been amazing to watch the shattered star get sucked inward by gravity, dramatically deflating like a punctured balloon. The material of a half million Earths suddenly packed itself into a globe smaller than Brooklyn. Laws of physics that normally keep objects apart but fail in places like supernovae (and subway cars) allowed this sun, bigger than our own, to collapse down to a radius of *only six miles*.

Ever-strengthening gravity imploded its atomic contents and fused them into a compressed swarm of neutrons, with some packed leftover protons and electrons elbowing themselves in vain for a little breathing room. Dense or hard are pathetic understatements. The average density of Crab material is the same as a sugar cube containing every American automobile. Imagine a one-inch cube with the weight of 100 million cars. Or, how's this: The star's present density would be equaled by an aircraft carrier crushed down to the size of the ball in a ball-point pen. Except, here there isn't merely a tiny speck of the stuff, but a sphere 12 miles across containing nothing but.

Amazingly, this is the same density found in every atomic nucleus in your body and everywhere else. So in a way, the Crab neutron star seen through your eyepiece is one giant neutron, 1/200th the width of the moon.

We usually think of star surfaces as gassy and lacking solidity. (The sun's vaporous visible photosphere is less dense than water.) But the Crab's surface is something else. Unimaginable gravity has forced its broken atom fragments into a kind of lattice, its exterior skin a spherical glasslike structure a hundred thousand trillion times stiffer than steel. It doesn't need to be insured. You can't damage it.

A half mile beneath this impenetrable crust, the star turns liquid yet becomes even more dense, but nonetheless boasts a curious super-slipperiness that lets the interior effortlessly spin at a different rate than the surface. Then, only a few miles down at the center, lies a mystery. Nobody knows what's there. But the sky's the limit. Earlier this year, researchers found tiny stars made of pure quarks, fundamental particles that combine as threesomes in every atomic nucleus. Solely in ultradense minuscule stars do they dwell in naked, unattached purity.

So this is what lurks behind Saturn in July, a crushed superball bathed in forbidden light, whose color mutates from the effort of fighting its way out of the sticky gravitational epoxy — and onward to our eyes and brains. A qualified candidate for the top-ten list of strangest places your telescope can visit — and worthy of more than the media's 15-minute allotment of fame.

Bob Berman's "Strange Universe" column is a monthly feature in Astronomy. Berman also is the author of two wonderful guides for astronomers: Secrets of the Night Sky *and* Cosmic Adventure.

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For more information, contact Jörg Dietrich, Stichwort: IAYC 2002, Babette, Koch, Weg 2, Zimmer 223, D-53121, Bonn, Germany; (49) 228 624674; e-mail, info@iayc.org; website, http://www.iayc.org/2002.

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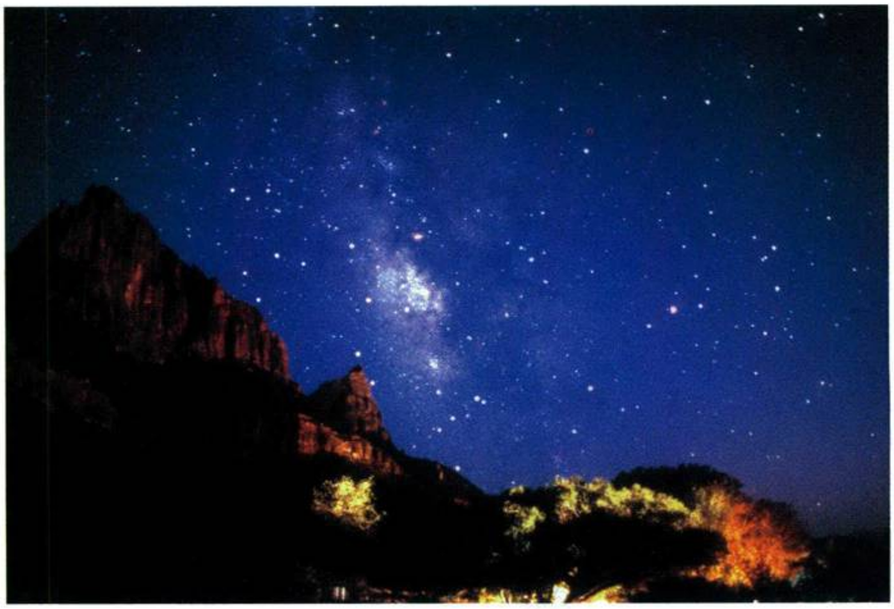
Jerry Schad

The rich summer sky provides magnificent views of the Milky Way.

JULY 7–13

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JULY 11–13

Table Mountain Star Party

Table Mountain, near Ellensburg, Washington. An annual gathering of people interested in astronomy and its many related topics. Programming is provided for everyone from the seasoned astronomer to the beginning novice. Late registration deadline is July 1, 2002. For more information, contact the Ellensburg Chamber of Commerce, (509) 925–3137, or Marcie Roundtree, lmround830@aol.com; website, http://www.tmspa.com.

JULY 12–13

Arkansas Star Party

Devils Den State Park, West Fork, Arkansas. Sponsored by the Arkansas-Oklahoma Astronomical Society. For more information, visit their website, http://www.aoas.org/.

JULY 12–14

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JULY 12–14

Gateway to the Universe Star Party

Munro Family Campground, Powassan, Ontario. Sponsored by the North Bay Astronomy Club. A private, non-electrical camping area is provided for all participants adjacent to a family campground with electricity and beach. Guest speakers, commercial displays, used treasures swap table, and new and renewed friendships. For more information, contact Tom Ouellette, (705) 474–7666, or Merlin Clayton (705) 472–1182; e-mail, galaxy@efni.com.

JULY 12–14

Prairie Grass Stargaze

Jeffers Petroglyphs Historic Site, Comfrey, Minnesota. Many petroglyphs dating to over 5,000 years old can be viewed in a natural prairie setting. Talks on Native American folklore and astronomy will take place in the evening. For more information, contact Don Franck at DFranck@aol.com, or Thomas Sanders at Thomas.Sanders@mnhs.org; website, http://hometown.aol.com/dfranck/Stargaze.htm.

JULY 12–14

RocheStar Fest

Lewis S. Wolk Observatory, Ionia, New York. Sponsored by the Astronomy Section of the Rochester Academy of Science. For more information, contact Lori Englund at ASRAS, P.O. Box 20292, Rochester, NY 14602; e-mail, lenglund@frontiernet.net; website, www.rochesterastronomy.org.

JULY 31–AUGUST 3

ALCON 2002

University of Utah, Salt Lake City, Utah. Sponsored by *Astronomy* Magazine, the Salt Lake City Astronomical Society, and the Astronomical League. ALCON 2002's mission is to provide a first-class astronomical convention that will allow both knowledgeable amateur and professional astronomers to gather together and exchange ideas. For more information, contact Lowell Lyon, bolide@sisna.com; website, http://www.alcon2002.org/index1.html.

AUGUST 2–11

Summer Star Party

Shady Pines Family Campground, Savoy, Massachusetts. Spend one day or ten at the 11th annual Summer Star Party – the choice is yours. SSP is family oriented and a great place to spend a summer vacation. For more information, contact Don Urban, (201) 768–3295; e-mail, donurban@rockland astronomy.com; website, www.rocklandastronomy.com/entry-page.htm.

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Add your events to our online calendar at http://www.astronomy.com.

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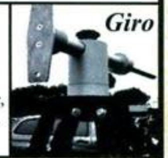

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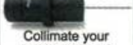

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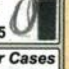

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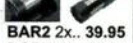

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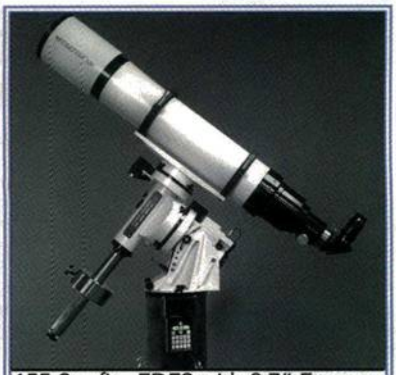

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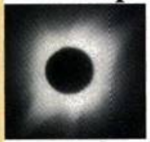

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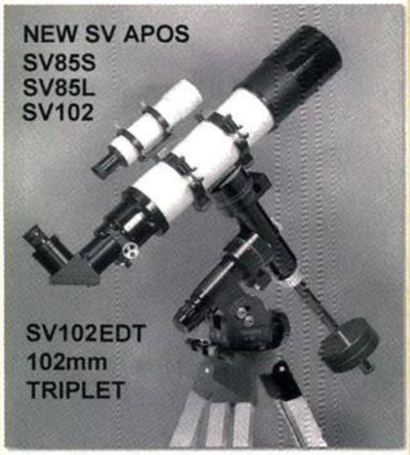

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Alaskan aurora photograph by Mike O'Leary

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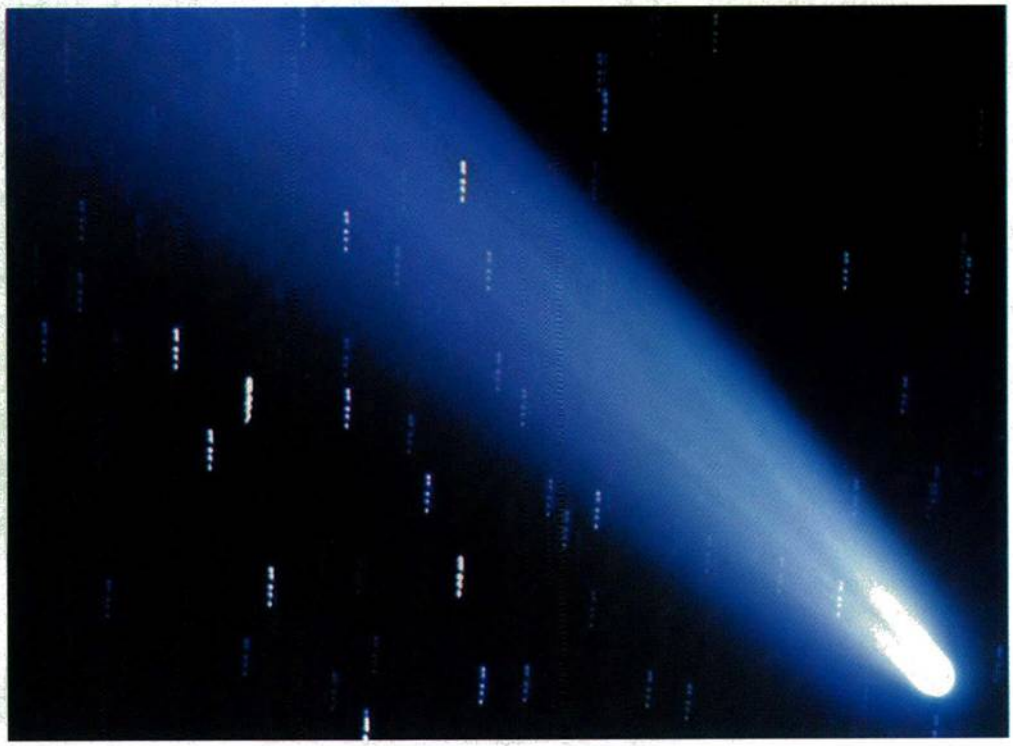
COMET IKEYA-ZHANG

Farewell to a Comet

I learned of comet Ikeya-Zhang from a colleague at the Philippine Astronomical Society when he invited me to an observing session in March. The comet was then visible in the western sky after sunset. As I was unable to attend, I thought that I had lost the opportunity to observe the famous comet. Instead, I searched the Internet for photos.

But to my delight, I discovered that the comet would again be visible in early April. After doing some research on the Internet, I learned that the best time to observe the comet would be on April 14, just before sunrise. So the Philippine Astronomical Society organized an observation session on that night in Pila-pila, Binangonan, Rizal, about 25 miles east of Manila on the island of Luzon. The site is a favorite for observing; it is a large stretch of land used for rice paddies during rainy months, but the soil becomes firm enough in summer to hold the weight of telescopes. The area is free of light pollution.

Peter Tubalinal and I arrived at about 10:30 P.M. on the night of April 13. Three other members were already setting up their scopes, while Edna Azucena, a friend and science teacher, was busy setting up a tent. Between the six of us, we had two sets of binoculars and three telescopes. By 1 A.M. we were all set, and we began to scan the skies. As a bonus, we saw five meteors, a bright bolide, and two satellites. To the north-



Comet Ikeya-Zhang

RÉMI LACASSE

(105mm lens at f/5, ST-10E digital camera, composite of five 1-minute exposures taken March 22, 2002)

Aurora over Schwatka Lake, Yukon, Canada

TI SHEFFIELD

(20mm lens at f/2.8, Fuji Provia 400 film, 20-second exposure taken October 3, 2001)

Comet Ikeya-Zhang, between M33 and M31

JIMMY WESTLAKE

(50mm lens at f/2, Kodak 400 film, 2-minute exposure taken March 31, 2002) east, we observed the stars of the summer triangle. Deneb and Lyra were visible slightly above the horizon, while Vega shone from a little higher in the sky.

By 1:30 A.M., we still had not seen Ikeya-Zhang, but we identified Alpha and Beta Centauri, as well as the four bright stars of the Southern Cross. As Edna was not accustomed to observing, we had fun showing her these prominent summer stars.

We continued to wait. The night was cold and windy, making it difficult to do any astrophotography. By 4:15 A.M., we knew the comet should have been visible, but it was nowhere to be seen. I began to feel discouraged.

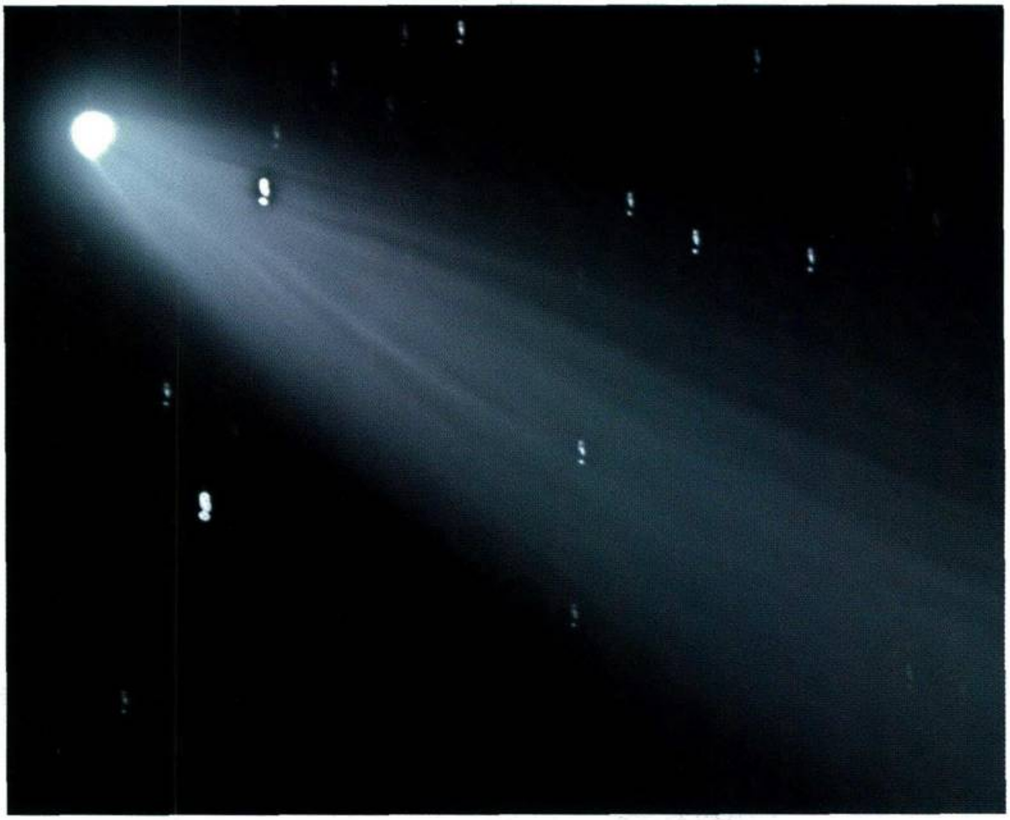
Finally, we scanned the northeastern skies and found a dim, fuzzy object. With the aid of binoculars, we discovered that the object was the coma of the comet. Excitedly, we focused our telescopes on the comet.

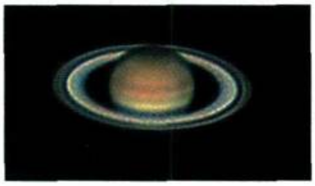
At last, the beautiful comet that I had nearly missed shone in the sky above me. With its tail slanting toward the north, the bluish-green comet appeared to be about 11° above the horizon.

We had about thirty minutes of observing time before the golden rays of morning sunlight filled the sky. I took full advantage of this time, admiring the beauty of the comet through the telescope.

While two of my companions tried their best to capture a photo of Ikeya-Zhang, the strong wind prevented them from recording it on film.

Still, the night was a success; we were all thrilled to have this rare chance to view a historic comet. The person who appeared the most ecstatic was Edna; this was a completely new experience



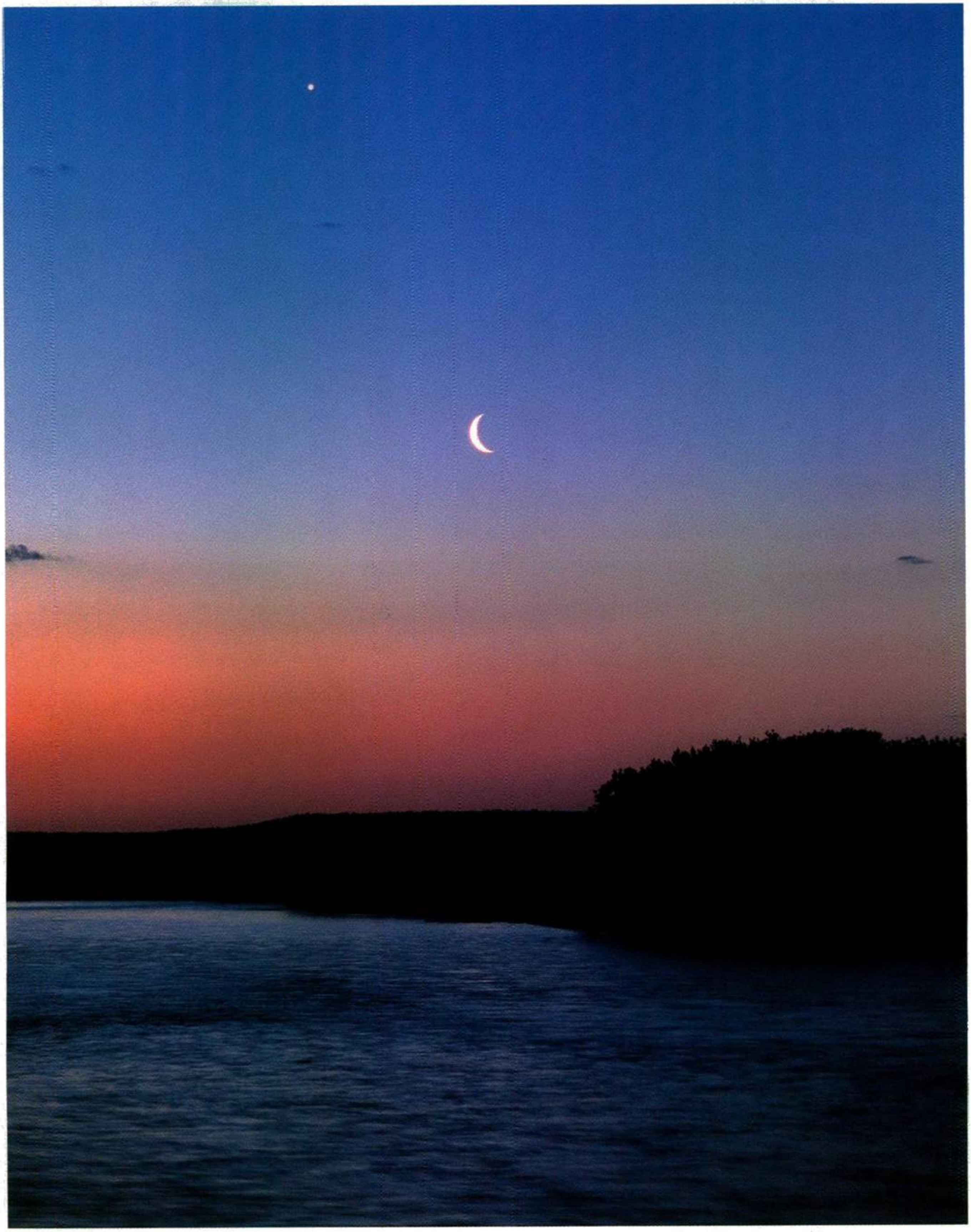


Top: Comet Ikeya-Zhang
PAUL ZELICHOWSKI
(10-inch reflector at f/4.5, Starlight Xpress CCD camera, composite exposure)

Right: M13
GARY STEVENS
(4-inch apochromatic refractor at f/5, ST-8E CCD camera, composite exposure)

Above: Saturn
CHRIS SCHUR
(12.5-inch reflector at f/5, SBIG 7E CCD camera, composite exposure)

Opposite page: Moon and Venus over Yellowstone River
JOHN MCNEAL
(70mm lens at f/4, Fuji 100 slide film, 5-second exposure)



for her, and one that she can pass on to her students.

We enjoyed the view until shortly after 5 A.M., when the soft, early morning light began to brighten the sky. We each bid the comet farewell with one last look through the telescopes. As Ikeya-Zhang will not return to the Philippine sky until November 2367, it was a once-in-a-lifetime opportunity. ◼

Bernie Esporlas is a member of the Philippine Astronomical Society in Manila, located in the Philippines. View its website at http://www.geocities.com/philastrosoc.

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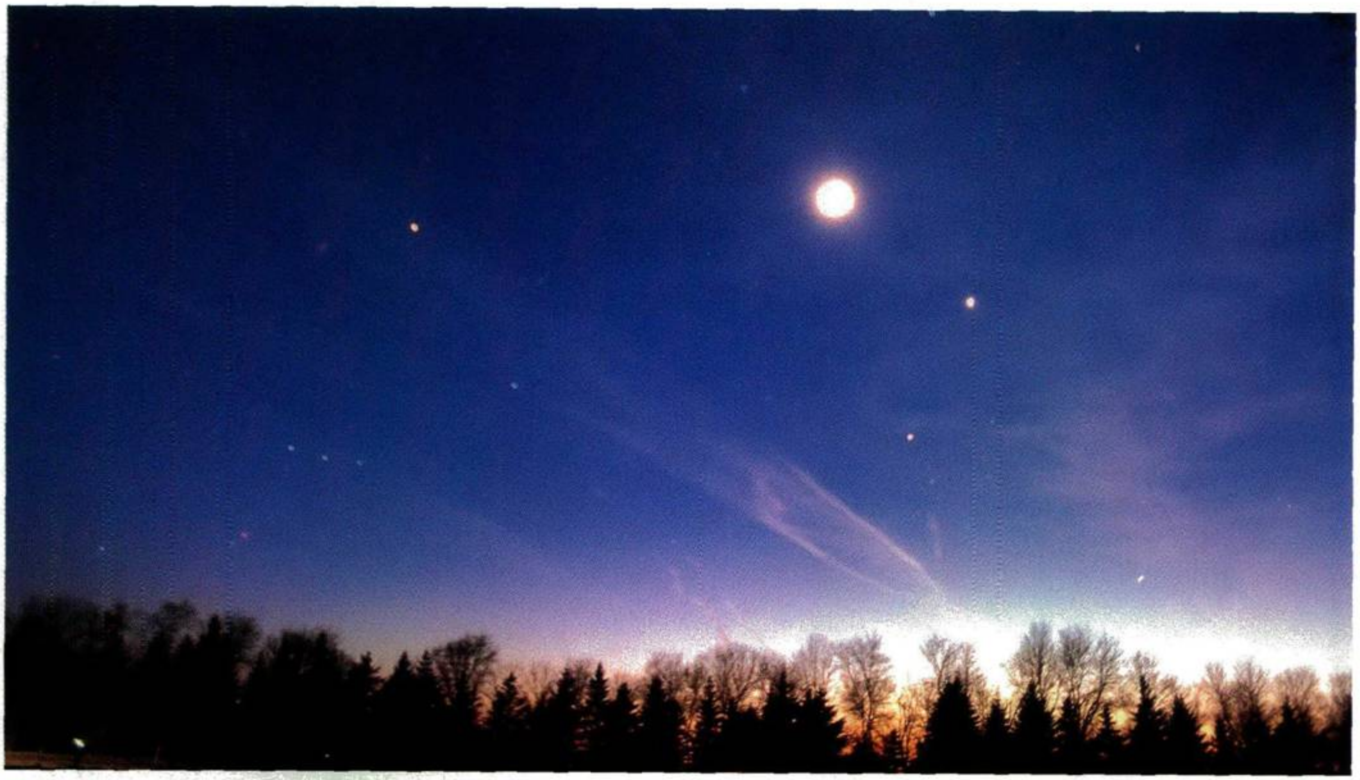
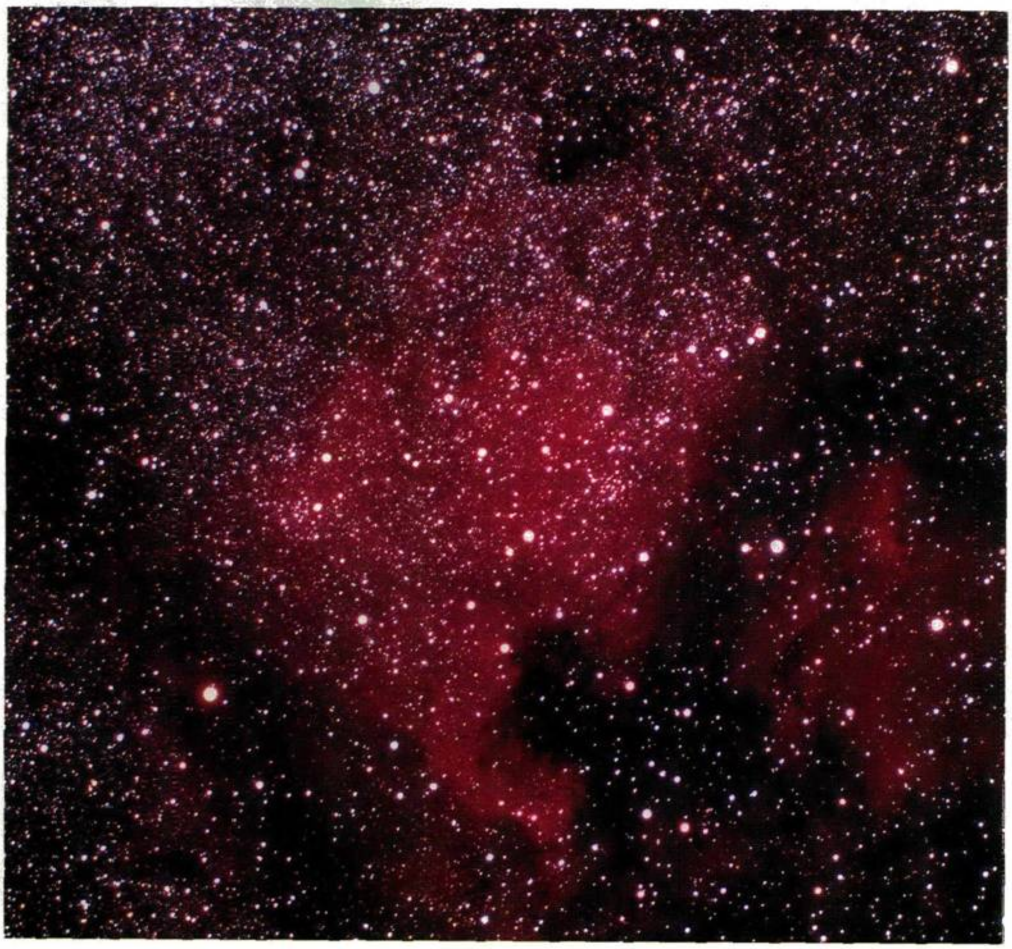




Opposite page, top: M81

GARY STEVENS

(6-inch refractor at f/8, SBIG ST-8E CCD camera, composite *exposure)*

Opposite page, bottom: Moon

MATHEW RUSSELL

(11-inch SCT at f/10, SBIG ST-10E CCD *camera, .3-second* exposure taken February 22, 2002)

Top: Conjunction of the moon and Venus

CARLA WEHLER

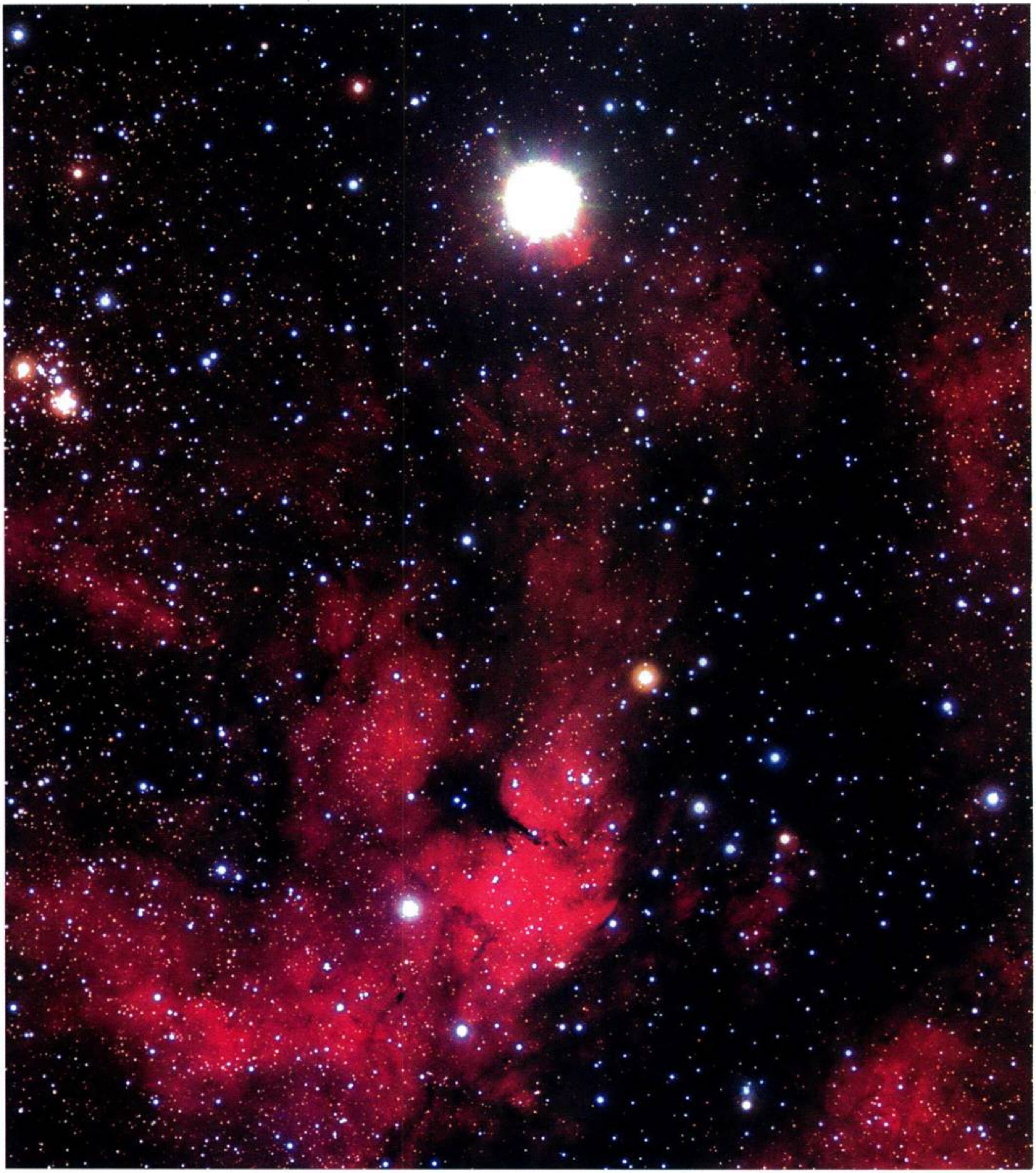
(28mm lens at f/2, Elitechrome 200 film, 5-second exposure taken April 26, 2001)

Left: NGC 7000

LEE C. COOMBS

(70mm lens at f/5.1, Elitechrome 200 film, 60-minute *exposure* taken August 11, 1999)

This month's best astrophoto



Emission Nebula IC 1318 in Cygnus

CHUCK VAUGHN

(130mm refractor at f/8, Kodak Tech Pan film, composite exposure)

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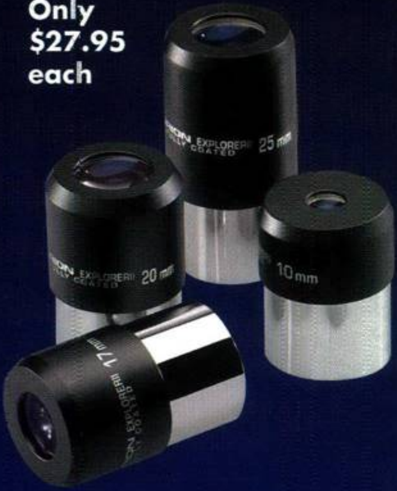
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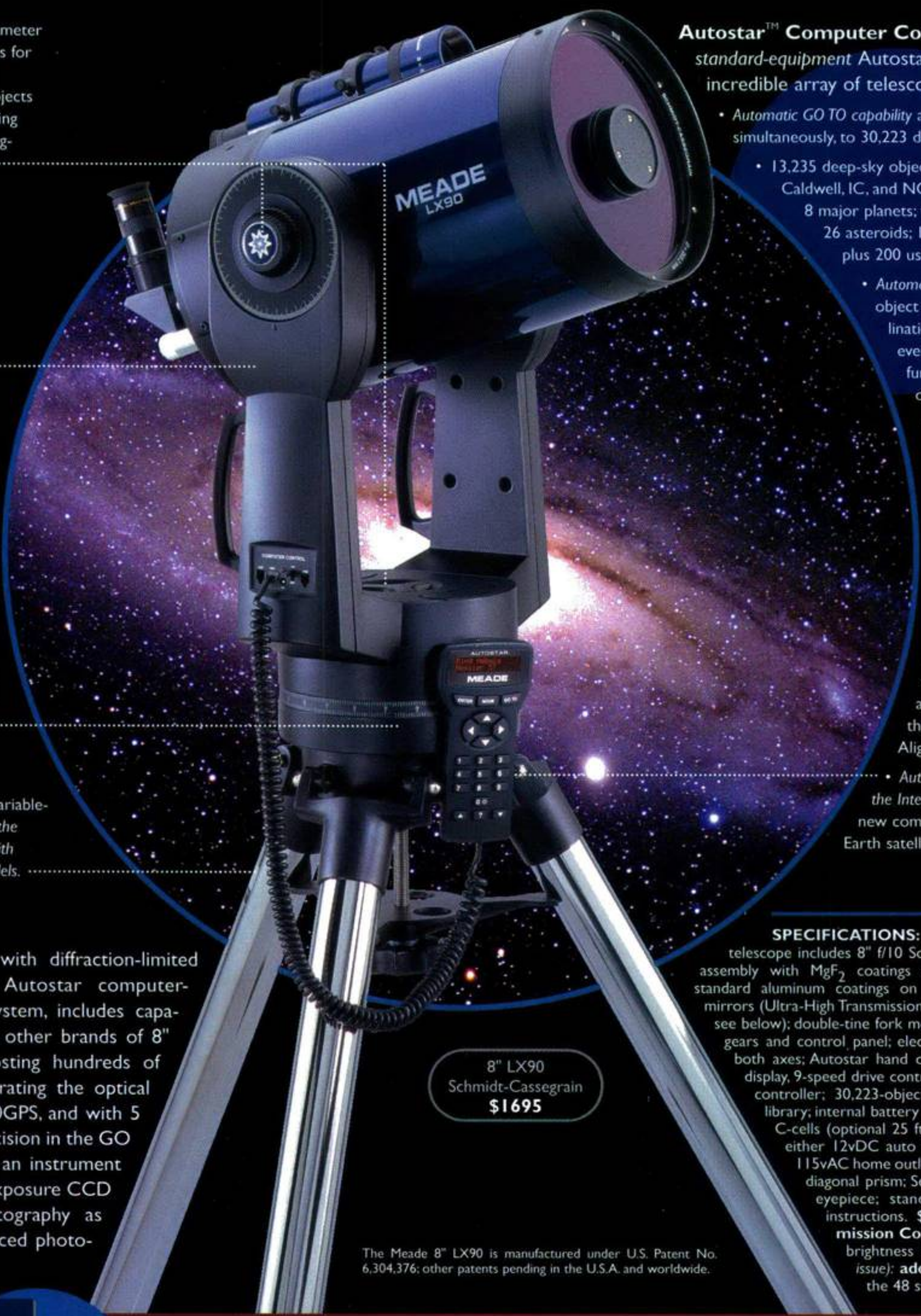

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